VII. *The Exact Histological Localisation of the Visual Area of the Human Cerebral Cortex.*

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Communicated by Dr. Mott, *F.R.S.*

Received May 11,—Read June 14, 1900.

[Plates 9–11.]

Introduction.

The object of the present paper is to define by histological methods the exact limitations of the visuo-sensory area of the human cortex cerebri. The investigation to be described has occupied upwards of three years. It was commenced during the summer of 1896 in the pathological laboratory of the County Asylum, Rainhill, Lancashire; it was continued during the next three years in the physiological laboratory of Mason University College, Birmingham; and it has been completed in the pathological laboratory of the London County Council at Claybury. Owing to the remarkable facilities for research granted to workers in the last-named laboratory, it has been possible to bring this investigation to a much more rapid conclusion than would otherwise have been possible.

A general summary of the paper follows this introduction, and it is succeeded for convenience of reference by a list of the sections into which the paper is divided.

General Summary.

Previous Research.

The previous research concerning the human visual area has been carried out in three directions.

(1) The study of lesions causing blindness.

(2) The study of the myelination of the corona radiata.

(3) The histological examination of "occipital" or "calcarine" cortex as regards—

(*a*) Cell form.

(*b*) Subdivision of this variety of cortex into layers.

(*c*) The modifications caused in (*a*) and (*b*) by long-standing blindness.

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Examination of the literature on the first two subdivisions demonstrates the extreme diversity of opinion which exists regarding the situation of the primary visual area of the cortex.

The object of the present research has been to indicate the exact region of the cortex to which the visuo-sensory function is limited. For this purpose it has been unnecessary to pay attention to the special neuronic structure of this portion of the cerebrum, but the general histology of the cortex referred to in (3), (*b*), and (*c*) has been considered minutely in the third section of this paper.

The Exact Distribution of the "Occipital" Lamination.

(1) The "occipital" lamination in the region of the calcarine fissure has been histologically mapped out, in six normal and pathological brains, as a well defined cortical area.

(2) The general distribution of this area is as follows. It occupies—

(*a*) The body of the calcarine fissure, including the anterior and posterior annectants, and extending upwards to the parallel cuneal sulcus and downwards to the collateral fissure.

(*b*) The posterior part of the calcarine fissure extending to the polar sulci surrounding its extremities.

(*c*) The inferior lip of the stem of the calcarine fissure (including the superficial surface and lower lip of the cuneal annectant) nearly to its anterior extremity, just posterior to which the area tails off to a sharp point.

(3) The approximate outline of this area is consequently pear-shaped with the apex anteriorly and the thick end at the pole of the hemisphere.

(4) The area is much decreased in extent, but not in distribution, in cases of old-standing optic atrophy.

(5) In anophthalmos the area is much contracted as regards both extent and distribution. It occupies the usual position in the stem of the calcarine fissure, but only extends backwards as far as the posterior cuneo-lingual annectant, and it is confined to a portion of the inferior lip of the fissure and to the cortex between this and the collateral sulcus.

The General Histology of the Cortex Cerebri in the Region of the Calcarine Fissure.

(1) The following classification of layers has been adopted for the purposes of micrometer measurement:—

(*a*) The cortex of the area of special lamination which has just been described.

I. The superficial layer of nerve fibres.
II. The layer of small pyramidal cells.

IIIa. The outer granule layer.
IIIb. The middle layer of nerve fibres, or line of GENNARI.
IIIc. The inner granule layer.
IV. The inner layer of nerve fibres.
V. The layer of polymorphic cells.

(b) The cortex surrounding the area of special lamination.

I. The superficial layer of nerve fibres.
II. The layer of small and large pyramids.
III. The layer of granules.
IV. The inner layer of nerve fibres.
V. The layer of polymorphic cells.

At the junction of these two varieties of lamination an abrupt change takes place, the line of GENNARI suddenly ceasing, and the outer granule layer joining the inner one, the conjoined layer being approximately of the thickness of the former outer layer.

(2) The average of very numerous micrometer measurements of the cortex of the area of special lamination and of the neighbouring convolutions gives the following results :—

(a) In the area referred to, in cases of old-standing optic atrophy, the line of GENNARI is decreased nearly 50 per cent. in thickness, and the outer granule layer more than 10 per cent.
(b) On the other hand, in the cortex surrounding the area referred to, old-standing optic atrophy causes no modification of the lamination.
(c) In anophthalmos the conjoined outer granule layer and line of GENNARI (for the granules in the former layer are not sufficiently obvious to admit of easy micrometer measurement alone) are narrowed down to two-thirds of the normal thickness, the other layers of the cortex being approximately unchanged. This amount of narrowing is the same as that found in cases of old-standing optic atrophy.
(d) The majority of the layers of the cortex either inside or outside the area of special lamination do not vary appreciably in thickness as a result of age or chronic insanity, but there is an almost exact correspondence between the thickness of the conjoined first and second layers of the cortex and the degree of amentia or dementia existing in the patient.

Summary of Conclusions drawn from the present Research.

(1) The area located and described in this paper is the primary visual region of the cortex cerebri.

(2) The part of this area to which afferent visual impressions primarily pass is the region of the line of GENNARI.

(3) A marked contraction of the area in both extent and distribution, without absence of the line of GENNARI, occurs in anophthalmos.

(4) This area can probably be described as the cortical projection of the corresponding halves of both retinæ. In this projection the part above the calcarine fissure represents the upper corresponding quadrants, and the part below the lower corresponding quadrants of both retinæ.

LIST OF SECTIONS OF PAPER.

SECTION 1.—*The Occipital Lobe and the Calcarine Fissure.*

Boundaries of the Occipital Lobe.—The occipital lobe of the human cortex cerebri is now defined within much narrower limits than was previously the case. The following description is that adopted by SCHÄFER (1) (after EBERSTALLER), and the limits he assigns to this region of the cortex can be readily followed in the drawings illustrating a succeeding section of this paper. The occipital lobe is somewhat pyramidal in shape, with flat mesial and curved lateral surfaces. The mesial surface is bounded inferiorly by the calcarine fissure, anteriorly by the parieto-occipital sulcus, and superiorly by the upper border of the hemisphere. This portion is thus wedge-shaped, and passes superiorly over the upper border of the hemisphere into the external surface of the lobe. The external surface is defined antero-superiorly by

the external portion of the parieto-occipital sulcus and the posterior extremity of the intra-parietal sulcus, between which is an annectant gyrus connecting the lobe to the superior parietal lobule; and antero-inferiorly by the anterior occipital and lateral occipital sulci. The anterior occipital sulcus is a more or less transverse fissure (transverse occipital of ECKER), which at its upper extremity usually joins the hinder end of the intra-parietal sulcus, and at its lower extremity is frequently curved forwards. It is here separated from the lateral occipital sulcus by an annectant gyrus, which unites the occipital lobe to the post-parietal convolution. The lateral occipital sulcus extends from the lower extremity of the anterior occipital sulcus towards the posterior pole of the hemisphere, here, according to SCHÄFER, bifurcating and occasionally embracing the posterior end of the calcarine fissure. Between the calcarine and lateral occipital fissures is an annectant gyrus, which joins the posterior end of the occipital lobe to the third temporal gyrus. The occipital lobe, as above described, is thus seen to include only a portion of the pyramidal apex of the hemisphere. The portions of cortex which, as the lingual and fusiform gyri, were formerly included in the occipital lobe, are now described as parts of the temporal lobe. The lingual gyrus, lying between the calcarine fissure and the posterior part of the collateral sulcus, and being continuous anteriorly with the hippocampus gyrus of the limbic lobe, is thus considered a fifth temporal or, as SCHÄFER suggests, an infra-calcarine gyrus, whilst the fusiform gyrus situated between the collateral and third temporal fissures is similarly described as the posterior extremity of the fourth temporal gyrus. It may be added that the median portion of the occipital lobe, as above described, or cuneus, is connected at its anterior extremity by means of an annectant gyrus, the cuneal annectant, with the upper or occasionally the lower lip of the stem of the calcarine fissure. The cuneus is also connected to the lingual gyrus by two annectant gyri (anterior and posterior cuneo-lingual annectants) which cross in the depths of the calcarine fissure.

The Calcarine Fissure.—The following description of the calcarine fissure is abstracted from the admirable monograph of CUNNINGHAM (2), which owing to its completeness and accuracy leaves little to be added to our knowledge of this region of the cortex cerebri :—

"The parieto-occipital and calcarine fissures form upon the mesial aspect of the posterior part of the adult cerebral hemisphere a ≻-shaped figure. In this we recognise a 'stem' with two divergent branches. The 'stem' is prolonged obliquely downward and forward, and cuts into the gyrus fornicatus. . . . The calcarine branch proceeds backward in a horizontal direction towards the occipital pole. On this it ends by dividing into an ascending and descending branch. These are usually placed at right angles to the parent trunk. . . . Both the calcarine and the parieto-occipital branches of this fissural system lie in the human brain entirely on the mesial surface of the cerebrum."

The stem belongs to and is usually directly continuous with the rest of the calcarine

fissure, of which it forms a part. It is in most cases separated from the parieto-occipital branch by the gyrus cunei of ECKER, which has been already referred to in the description of the occipital lobe. In the calcarine division and about half an inch behind the bifurcation of the fissures is situated the anterior cuneo-lingual annectant of CUNNINGHAM, which, like the gyrus cunei, arises from the apex of the cuneus. This gyrus separates the anterior and deeper portion or stem of the calcarine fissure from the posterior and shallower subdivision, which is termed by CUNNINGHAM the fissura calcarina posterior, and which is subdivided into two parts near its posterior extremity by the posterior cuneo-lingual annectant gyrus. It will be seen later in this paper, that for convenience of description I have referred to the calcarine fissure as consisting of three subdivisions: a stem, a body which consists of the two cuneo-lingual annectants and the part between them, and a posterior extremity. This subdivision of the fissure is justified for the purposes of description by the usual large size of the posterior cuneo-lingual annectant and the frequency with which this is superficial, thus separating off the posterior extremity of the calcarine sulcus from the remainder. The primary division into a stem and a posterior portion is, however, the correct one, as it is founded on an embryological basis.

The development of the calcarine fissure is minutely described by CUNNINGHAM, in the monograph already referred to. Towards the end of the second or the beginning of the third month of intra-uterine life the precursors of the parieto-occipital and calcarine fissures appear synchronously, and include the primitive cuneus. These primary parieto-occipital and calcarine fissures shortly afterwards disappear, leaving however intact the portion which later on becomes the stem of the calcarine sulcus, and which is thus one of the primitive fissures of the cerebrum. "This portion alone assumes the responsibility of maintaining the intra-ventricular elevation which results in the calcar avis. Between the 5th and 7th months of intra-uterine life a secondary sulcus appears, as 'two' punctiform depressions, one on the occipital pole and the other midway between this and the hinder part of the anterior calcarine fissure or stem. These deepen and then show a tendency to run towards each other in a horizontal direction." The anterior of these depressions soon becomes the deeper, and later on joins the stem, the point of junction being visible in adult life as the anterior cuneo-lingual annectant. The junction between the posterior depression and the rest of the fissure occurs much later and in many adult brains, and commonly in the negro and the fœtus, it never takes place at all, the posterior extremity remaining usually as a short vertical fissure in the region of the pole. When, as is usually the case, the junction takes place, the site of this is indicated in the adult brain by the posterior cuneo-lingual annectant gyrus.

In concluding this description it is desirable to refer to certain of the sulci of the occipital region, which are of importance in connection with the boundaries of the area of special lamination in the region of the calcarine fissure, which will be defined in a later section of this paper. I have at various periods during the last three

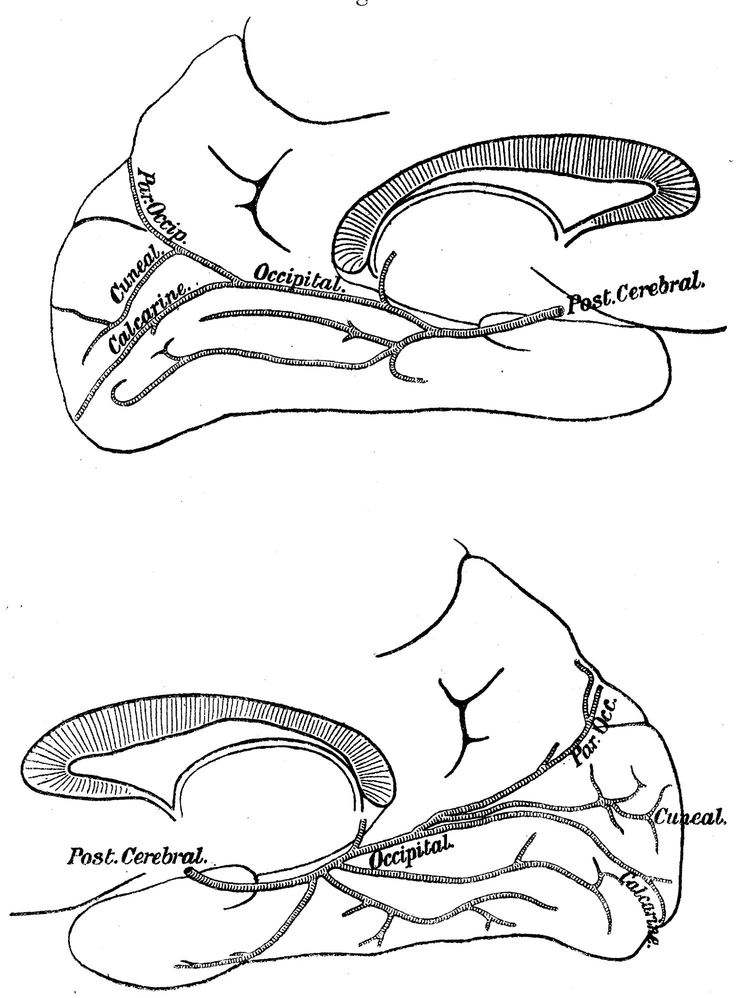
years examined small series of brains as regards the mode of ending of the posterior extremity of the calcarine fissure. This was done in order to determine whether or not the brains used during the present investigation gave a fairly accurate representation of this region. The results obtained from the different small series being contradictory, I have preserved in formalin, and recently examined, a series of 40 hemispheres obtained in the Claybury mortuary during the past three months. In the 40 hemispheres the calcarine fissure bifurcated at its posterior extremity in 35, and the average lengths of the upper and lower limbs were $\frac{5}{8}$ of an inch and $\frac{3}{4}$ of an inch respectively. The upper limb was present in 36 cases. Of these in 19 instances it passed above the pole for a variable distance over the external surface of the hemisphere, and in the remaining 17 it was entirely on the internal face of the hemisphere. The lower limb was present in 39 cases. Of these in 15 instances it was entirely on the internal face of the hemisphere, in 7 it passed below the pole ending on the inferior surface of the brain, in 8 it passed round the pole to its apex, and in 9 it extended above or across the pole to the external surface of the hemisphere. Consequently the lower limb was entirely on the inferior-internal aspect of the hemisphere in 22 cases, it extended to the outer surface of the brain in 9, and it ceased on the pole in 8.

This result agrees sufficiently with the average of my previous examinations, and with the drawings illustrating this paper, to render further examination unnecessary. With reference to the cuneo-lingual annectants, the anterior was superficial in 1 case only and the posterior in 8 cases. I have carefully examined the sulci of the occipital lobe in the same brains, in order to determine the relative frequency of the small fissures, to which I shall refer later in this paper under the names of the "parallel cuneal sulcus" and the "polar sulci." The former, which usually goes by the name of the "cuneal sulcus," lies parallel to the calcarine fissure, and is present in 5 out of the 6 brains figured in Section 4. The case in which it is absent is one of anophthalmos. Of the 40 hemispheres I have examined, it was typically present in 28 cases, it was irregular or complex in 10, and it was absent in 2 only. It is as a rule irregular in those instances in which a subsulcus of the calcarine fissure extends upwards into the cuneus. By the term "polar sulci," I refer to the small and more or less semilunar fissures, which are nearly invariably found surrounding the posterior extremities of the calcarine fissure, and which are frequently distinct from the anterior and lateral occipital fissures. They can be readily seen in the first five brains figured in Section 4. Whilst the inferior polar sulcus is almost invariably a distinct fissure, it is difficult to determine in many cases whether or not the superior polar sulcus is really a part of the anterior occipital fissure, owing to the frequent impossibility of being certain of the exact sulcus to which the latter term refers. I have consequently contented myself with accurately marking out all the fissures of importance in the illustratious referred to, and have only named those about which no doubt existed as to the nomenclature to be adopted.

The Vascular Supply of the Visual Area.

During the past three years I have performed a small series of carmine injections of the posterior cerebral arteries, in order to determine the exact vascular supply of the visual area. In each case I found that the occipital artery gave off two branches, of which the first entered the calcarine fissure. The second entered the parieto-occipital fissure, and either at once or during its course gave off a branch to the cuneus, which sooner or later entered the parallel cuneal sulcus. These two types are shown in fig. 1.

Fig. 1.

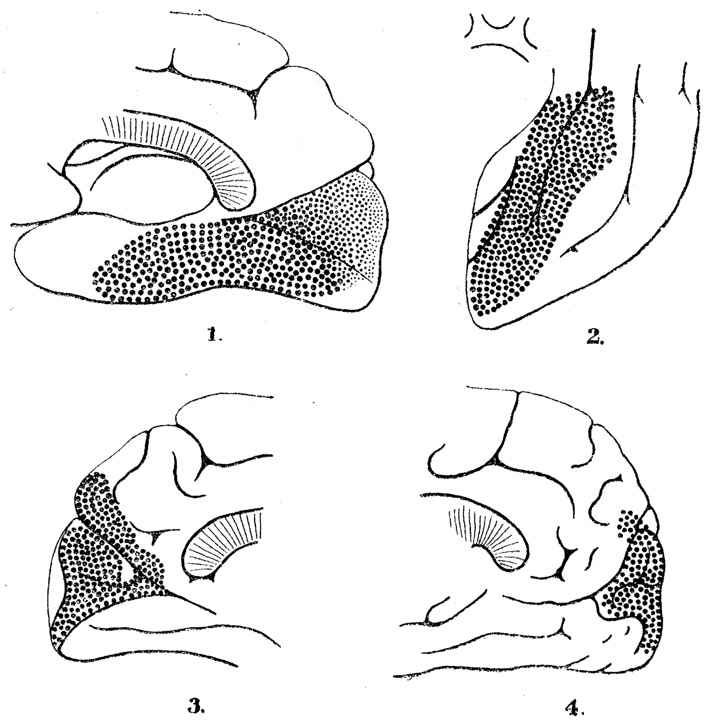


It was my intention to further investigate this matter when I found that I had been anticipated by MONAKOW (3), who had already published results identical in substance with the above.

It is, however, probably worth while to draw attention to certain types of vascular lesion in the neighbourhood of the calcarine fissure, which first led me to

begin the investigation of this matter, and which I have copied from numerous similar examples in the admirably kept pathological records of the County Asylum, Rainhill. Four of these are shown in fig. 2. In the first, the lesion occupies the areas of distribution of the cuneal and calcarine arteries, possibly also that of the parieto-occipital artery, and practically the whole of the temporal distribution of the posterior cerebral; in the second, it occupies that of the calcarine artery, and of some of the temporal branches of the posterior cerebral artery; in the third, that of the cuneal and parieto-occipital arteries; and in the fourth, that of the cuneal artery alone.

Fig. 2.



During the careful stripping of a large number of brains, this arterial distribution has been verified almost as satisfactorily as could be done by the injection method, and I have also found that a considerable amount of variation exists in different brains. The relative extent to which the anterior cerebral and the parieto-occipital arteries supply the hinder portion of the pre-cuneus varies considerably in different cases, as does also the part taken by the three subdivisions of the occipital artery and by the middle cerebral artery respectively in the supply of the cortex in the neighbourhood of the upper border of the hemisphere. This variation renders it unnecessary to investigate the subject more minutely, and it also affords a ready explanation of the different effects which may follow the same apparent vascular lesion. This is well seen in the third drawing in fig. 2, where, although the cuneal and parieto-occipital arteries are blocked, a portion of the depth of the parieto-

occipital fissure is intact as well as a little of the base of the cuneus. Probably both these unaffected regions drew their blood supply from the middle cerebral artery, and a comparison of the intact portion of the parieto-occipital fissure and the apex of the cuneus in this case with the visuo-sensory area in one of the brains figured in Section 4 will at once show how in a lesion of this description a part ot the fields of vision might be intact.

Section 2.

Almost since the beginning of the second half of the present century, but especially during the past twenty years, numerous observers have endeavoured by one or other of the experimental, the pathological, and the embryological methods to determine the exact regions of the cortex cerebri in which visual sensations are received and elaborated.

A general review of these investigations shows that cortical visual representation has been described as twofold, consisting of a primary region in each hemisphere for the reception of impressions passing from the corresponding halves of both eyes, and a secondary, possibly psychic, centre in each hemisphere connected in each case with the opposite eye. The former centres are proved to exist, and are variously placed by different observers in the whole or parts of the occipital lobes. The latter are doubtfully existent and doubtfully located in the angular gyri.

The hypothesis of a visual centre in the angular gyrus was originally advanced about twenty years ago by Ferrier (4), who found in the monkey that removal of one angular gyrus produced temporary blindness of the opposite eye, and that bilateral removal produced total blindness for a time, succeeded by lasting visual impairment of both eyes. This hypothesis received some support from the experiments of Schäfer and Horsley (5), who found that a bilateral lesion of both occipital lobes did not cause permanent blindness, but that hemianopsia resulted on the subsequent removal of one angular gyrus, and lasted till the animal's death three months later. Post-mortem examination, however, showed that the removal of the occipital lobes was not complete. The matter was finally settled by Schäfer and Sanger-Brown (5), who at two operations completely removed the cortex of both angular gyri of a Rhesus, and proved some months later by post-mortem examination that the destruction was complete. This animal did not at any time exhibit "any appreciable defect either in its visual perceptions or its ocular movements, or in the sensibility of the globe of the eye." In another case, in order to still further guarantee complete removal of the whole angular gyrus, including the bottom of the fissures bounding it, they produced "a gap in the surface of the brain of considerable depth. This operation *was* followed by a disturbance of visual perceptions, but the disturbance was not amblyopic, it was distinctly hemiopic. The condition lasted for a few days, gradually passing off, leaving vision unimpaired. . . . The result can be explained by the vascular disturbance which is produced in the occipital lobe by so radical a removal of

the neighbouring gyrus." The original hypothesis of FERRIER would now be obsolete had it not been recently revived on pathological grounds by SHARKEY (6), who, however, reports neither the results of perimetric examination of the retinæ in his cases, nor the microscopic extent and nature of the lesions found. Of the three cases he describes, in the first the patient died from the fall of a house: the eyes were not examined during life, and consequently the condition might have been either amblyopic or hemiopic; in the second, of embolism of the right middle cerebral artery, temporary loss of all the senses of the opposite side resulted, and seven years later absence of the right angular gyrus was found; and in the third practically total blindness and deafness coexisted with macroscopic intactness of the occipital lobes and bilateral softenings in the regions of the sylvian fissures, the child being considered by the friends to have seen and heard quite well prior to the lesion. The first case is, of course, valueless, and the second, if it proves anything, shows that the angular gyrus is *not* necessarily connected with either vision or any other sense. In the case of the third the blindness might be due to either double amblyopia or double hemianopsia, for numerous examples (as, for instance, the case of DÉJERINE and VIALET, reproduced in fig. 3) might be cited to show that macroscopic examination alone is quite useless as regards the determination of the extent of a lesion; and without proof to the contrary in the case under consideration the optic radiations may be considered to have been certainly involved.

The connection of the angular gyrus with the vision of the opposite eye is consequently very doubtful, although it is by no means improbable that this region of the cortex, together with other parts to be later on referred to, is concerned in the carrying on of visuo-psychic processes. In all probability the question of a crossed or a semi-projection of the retinæ, as regards visual ideation, cannot arise, as visual representation in contradistinction to visual presentation must of necessity be bilateral in each hemisphere, and in all probability more highly evolved in the majority of persons in the left hemisphere than the right.

The region of the cortex cerebri to which visual impressions directly pass is much more definitely located, and whilst different views exist as to the exact portion of the cortex concerned, the more or less complete agreement of experimental, clinico-pathological, and embryological investigations sufficiently conclusively proves that visual impressions from the right halves of both retinæ pass to the whole or part of the right occipital lobe, and from the left halves of both retinæ to the whole or part of the left occipital lobe.

By the experimental method SCHÄFER and SANGER-BROWN (5) have shown that in the monkey removal on one side of the whole occipital lobe alone results in permanent blindness of the corresponding sides of the retinæ or of the opposite halves of the visual fields, and that bilateral removal of both occipital lobes alone results in total permanent blindness. These results agree with those found by MUNK (7) to follow extirpation of the occipital lobes in dogs and monkeys, but differ in being absolutely

conclusive, as the operations were performed with antiseptic precautions, and the authors publish careful representations of the lesions found post-mortem. There is less substantial agreement, however, between the conclusions of SCHÄFER (8) and MUNK (7) as regards the question of definite retinal localisation in the occipital lobes. SCHÄFER, on the one hand, considers that the upper and lower zones respectively of each occipital lobe are connected with the upper and lower parts respectively of the corresponding lateral halves of both retinæ, the middle intermediate zone being connected with the middle part of the corresponding lateral halves of both retinæ. MUNK, on the other hand, whilst agreeing with SCHÄFER as regards the connection of each occipital lobe with the corresponding halves of both retinæ, states that the lateral half of the left occipital lobe corresponds to the lateral (temporal) half of the left retina, and the medial half to the median (nasal) half of the right retina, and that the lateral half of the right occipital lobe corresponds to the lateral (temporal) half of the right retina, and the medial half to the median (nasal) half of the left retina. He thus locates a separate macula lutea corresponding in both cases to both eyes on the convexity of each occipital lobe, in place of the juxtaposed middle zone maculæ of SCHÄFER.

Allowing for the difference in extent and distribution of the occipital cortex in monkeys and man, which will be referred to later, it is probable that the results of SCHÄFER are more nearly in accord with the conditions probably present in man than are those of MUNK.

VITZOU (9) has recently reported a remarkable case where complete removal of the occipital lobes in a young monkey caused total blindness, which began to pass off three and a half months after the operation. After two years and two months, by which time vision was apparently normal, on re-operating he found the gap filled up with nervous tissue. He completely removed the apparent newly developed occipital lobes with the result that the animal became permanently and totally blind. VITZOU concluded from his examination of the tissue removed that it was a new formation of nervous tissue, and that the occipital lobes could consequently grow again after excision. This is quite contrary to all we know of neuronic development, and a more probable explanation in my opinion is that at the first removal the anterior parts of the visuo-sensory areas, which in man, as I shall show later, extend forwards as far as the splenium of the corpus callosum, were not removed, and probably were not entirely, owing to the youth of the animal, in a mature condition of functional activity. During the years that the animal lived after the first operation, the brain would naturally fill up the vacant space rather than stimulate the expansion of the skull, and the undeveloped anterior extremities of the visuo-sensory cortex would gradually mature, the sight of the animal being apparently normal but really relatively defective. It may be added that these considerations are only brought forward as a possible explanation of the facts and as an alternative to what I consider the less probable one of VITZOU.

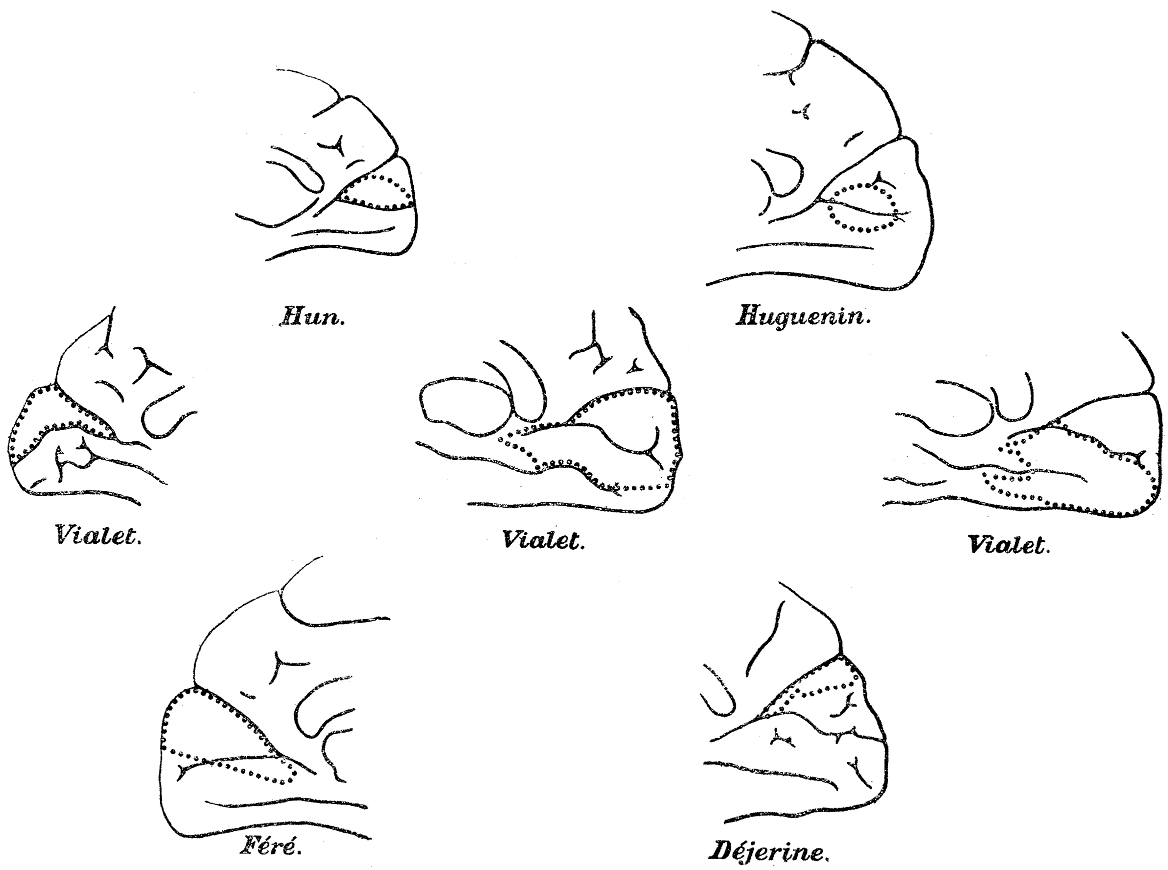
The immense quantity of literature which has been published on the clinico-pathological aspect of this subject renders it impossible to give even a brief *résumé* of all the facts adduced, but fortunately a considerable amount is relatively useless, owing to absence of precision, or only valuable as supporting statements previously advanced. The earliest recorded case bearing on the subject was published by CHAILLOU (10) in 1863. In this case permanent right hemianopsia coexisted with the absence of a large area of cortex on the median surface of the left occipital lobe. During the next twenty years numerous similar cases were reported, and, in 1884, STARR (11) collected and analysed 27 cases of lesions of the occipital lobes and neighbouring parts combined with hemiopia. He concluded from a study of these cases that the visual area lies in the occipital lobes, that the exact site is doubtful, and that a lesion on either the convex or the median surface may cause hemiopia. He alluded to the discovery of WERNICKE (1881) that the optic radiations passed just beneath the cortex of the angular gyrus, and noted how a lesion of the angular gyrus might cause visual disturbance by implication of these fibres and thus explain the results obtained by FERRIER in his extirpation experiments.

In 1886 SEGUIN (12) was able to collect 40 cases, of which 16 were cortical and 4 nearly identical and practically in the region of the calcarine fissure. He, like STARR, drew attention to the position and direction of the fasciculus of GRATIOLET and WERNICKE (first described in 1854) under the inferior parietal lobule and angular gyrus, and stated that it passes to the cuneus chiefly. SEGUIN consequently located the visual area on the inner face of the occipital lobe.

HUN (13), in 1887, reported what is probably one of the most important cases yet recorded. In this patient there existed a defect of the fields of vision in the lower left quadrant of each (upper right quadrant of each retina), together with atrophy of the lower half of the right cuneus. This lesion is figured amongst the drawings in fig. 3 (p. 178), and is one of the most circumscribed I have been able to find in the literature of the subject. Its bearing on the elucidation of the problem under consideration will be referred to later. HUN concluded that the optic fibres from the right upper quadrant of each retina go to the lower half of the right cuneus, and from the right lower quadrant to the adjacent part of the right median occipito-temporal convolution. From another case, first reported by MONAKOW, he concludes that on the convex surface of the (? left) occipital lobe are complete visual perception and recognition, the median surface of the occipital lobe being concerned merely with simple visual sensations, or, in other words, being the visuo-sensory area of the cortex. In 1892 HENSCHEN (14) had found in his hospital at Upsala records of nearly 40 hemiopic cases with post-mortem reports, which number SEGUIN six years earlier had only found in the whole of the literature, and, at the time of writing, HENSCHEN estimated the probable number of recorded cases at 160 or more. HENSCHEN confines the visual area within narrower limits than any other observer. He concludes (p. 177) that a lesion limited to the calcarine fissure alone can induce

complete hemianopsia, and that there is not any absolute reason for extending the area further than the lips of the fissure. He also states that in one of his cases the fibres to the ventral retinal quadrant lie ventrally in the optic radiation.

Fig. 3.



In 1893 VIALET (15) wrote an important monograph on the cerebral centres of vision, in which he described at length the microscopic extent of the lesions found in five cases of hemianopsia under the care of DÉJERINE.

The first case he refers to is figured under DÉJERINE in fig. 3, and is one of left homonymous hemianopsia, and, though macroscopically only the anterior fourth of the cuneus is involved, VIALET shows that microscopically there exists a lesion of the anterior two-thirds of the cuneus, the anterior half of the calcarine fissure, the bottom of the perpendicular internal fissure, and the foot of the cuneus, with an extension into the foot of the hippocampus. The second, of pure right hemianopsia involving macroscopically the cuneus alone, includes microscopically the whole of the cuneus, except a single islet of cortical substance, and also both lips of the calcarine fissure. These examples beautifully illustrate the extreme caution with which macroscopic lesions, unverified, as in the cases published by SHARKEY, by microscopic examination, must be accepted.

In 1894 VIALET published two other cases of hemianopsia, also figured on p. 178, fig. 3, in the one of which the lingual and fusiform lobules were affected, and in the other the cuneus and the lingual lobule. He consequently concluded that the visuo-sensory area occupies the whole extent of the internal face of the occipital lobe, and is limited anteriorly by the perpendicular internal fissure, above by the upper border of the hemisphere, below by the inferior border of the third occipital convolution, and behind by the occipital pole. He thinks that the anterior limit is the least certain of these, and that the calcarine fissure is very important for developmental, vascular, and structural reasons.

VIALET'S first paper was shortly followed by one by BRISSAUD (16), who attempted, by tracing the course of the optic radiations to their cortical distribution, to limit the visuo-sensory area to the neighbourhood of the inferior part of the calcarine fissure, that is to say, to the lingual lobule. He emphasised the importance of the calcarine fissure, and showed that owing to its varying shape, its bifurcation, and its occasional passage round to the external surface of the cerebrum, a lesion on the outside of the hemisphere might cause blindness. In his scheme he marked out the lingual and fusiform lobules, and to a less important degree extended the area practically to the anterior part of the fourth and fifth occipito-temporal convolutions. He attempted to show that none of the fibres of the optic radiations could pass through the calcarine fissure to the cuneus, owing to a dense "*faisceau festonné*" of vertical fibres connecting the cuneus through the calcarine fissure to the lingual lobule, and that therefore the cuneus could not possibly be included in the visuo-sensory area.

VIALET (15), in a later paper, disputed BRISSAUD'S statement, and attempted to show that fibres of projection, belonging to the optic radiations, pass upwards through the "*lame festonnée*" of BRISSAUD and ascend into the cuneus.

The important work of MONAKOW (17) and of many other observers might well be referred to in this connection, were it not that the foregoing selection gives a sufficiently full account of the subject for the purposes of the present paper.

Finally, from the embryological standpoint, the invaluable researches of FLECHSIG (18) have added many facts of great importance to the elucidation of the question under consideration. He separates from the radiations of GRATIOLET a bundle, "optic radiations in the narrower sense," which is medullated in the new-born infant, and passes directly from the external geniculate body to the part of the occipital cortex immediately adjacent to the calcarine fissure, and especially to that portion possessing the line of VICQ D'AZYR; and he considers that the remaining fibres of "the optic radiations in the wider sense" of GRATIOLET may be in large part not corticipetal but corticifugal in nature. He provisionally includes in the visuo-sensory area the whole inner surface of the occipital lobe, and a narrow zone at the inner border of the convex surface of the hemisphere, and expresses uncertainty as to where exactly in this region the visual sense area is located.

The view of FLECHSIG is practically that adopted by BARKER (19) in his recent

admirable text-book, and it much resembles the modifications advocated by SEGUIN and VIALET. It, however, affords strong support to the opinion of HENSCHEN, who limits the area of the cortex concerned in visuo-sensory activity to the calcarine fissure alone.

In the foregoing account I have purposely omitted any reference to the numerous lesions on the external surface of the brain, or in the white matter, which have been followed by hemiopia, as these can all be explained by supposing that the lesion penetrates sufficiently deeply or is so placed as to involve the optic radiations of GRATIOLET.

SHARKEY (6) is, for this reason, probably quite correct when he expresses the opinion that lesions on the outer surface of the hemisphere may cause hemiopia. As I shall show later also in this paper, the calcarine fissure and the visuo-sensory area frequently pass round the pole of the hemisphere and encroach on the outer surface of the cerebrum. A lesion in this region would consequently cause a more or less complete hemiopic defect of vision without any necessary involvement of the optic radiations.

I have in fig. 3 (p. 178) reproduced a few of the more typical of the very numerous lesions recorded during the past 37 years, as it is impossible to refer to them all in detail without losing more in lucidity than would be gained by completeness.

The case of HUN (13) (fig. 3, 1) is particularly interesting, owing to the small size of the lesion and to the fact that it was evident clinically as blindness of the left lower quadrant of each visual field, or the right upper quadrant of each retina.

The case of HUGUENIN (20) (fig. 3, 2) is one of a small tuberculous tumour situated as in the diagram. Of course it may have affected the neighbouring parts, but it is, at any rate, focussed on the greater part of the exactly-defined area to which I shall later on draw attention.

The three cases copied from VIALET (fig. 3, 3–5) illustrate lesions, all resulting in hemianopsia, of the cuneus alone, of the cuneus and the fifth temporo-occipital convolution, and of the fourth and fifth temporo-occipital convolutions respectively, and are the foundation of his view that the whole of the cuneus and of the lingual and fusiform lobules are concerned in the formation of the visuo-sensory area.

The case of FÉRÉ (21) (fig. 3, 6) is introduced as a curiosity, probably due to an abnormal arterial supply of this region, but a comparison of his figure with the drawings given later in this paper will at once demonstrate why the lesion was followed by hemianopsia.

The case of DÉJERINE (22) (fig. 3, 7), reported clinically by him and pathologically by VIALET, has been already referred to as interesting owing to the small extent of the macroscopic and the large extent of the microscopic lesion.

From the foregoing review of the literature on the subject of the human visual area, it is probable that in man the calcarine fissure and the regions immediately bounding it are the parts especially concerned in the reception of visual impressions

from the halves of the retinæ on the same side, or of the visual fields on the opposite sides. When, however, this conclusion is compared with the results of experiments a serious discrepancy appears, for in the monkey the whole of the occipital lobes apparently subserves the visuo-sensory function. This difference can only be satisfactorily explained by a careful and systematic histological examination of the whole of the occipital cortex in man and monkeys.

SCHLAPP (23) has recently mapped out the cortex of the cerebral hemispheres of the monkey into three general types, of which the most posterior or "occipital" occupies approximately the region found by SCHÄFER and MUNK to cause blindness on excision. SCHLAPP'S conclusions, though only approximate, may be considered to confirm the results of experiment, at any rate until the matter is worked out in greater detail.

In the case of the human cortex, whilst it is generally acknowledged that the "occipital" lamination exists in the region of the calcarine fissure, no systematic investigation has hitherto been undertaken. CAJAL (24) in his recent publication limits the sight-cortex to the inner flat surface of the occipital lobes, without entering into even approximate detail. HAMMARBERG (25) in 1898, in his illustration of occipital cortex reproduced in diagrammatic form a section of the "gyrus occipitalis superior," but as he did not show by an accurate drawing the exact region from which the section was taken, the statement that the lamination occurs here is from a localisation point of view, valueless.

It is the object of the present paper to accurately define the limits of the visuo-sensory area in man, and to show that these are constant. It is also proposed to demonstrate that the area to be defined *is* the primary visual area by a description of the changes which exist in this region alone in cases of long-standing blindness. The preceding review and especially the cases of HUN and HENSCHEN will also, I hope, make clear that the area to be defined possesses the same retinal projection in man, as does the entire occipital lobe of the monkey in the scheme of SCHÄFER.

SECTION 3.

Since the early part of the present century, through the observations of GENNARI, VICQ D'AZYR, BAILLARGER, and other workers, it has been known that the cortex cerebri in the region of the calcarine fissure, possesses a characteristic structure owing to the existence in the centre of the grey matter of a white line which is readily visible to the naked eye. Numerous observers have during the past thirty years divided the cortex of this region into definite layers, but, largely owing to differences in the layers described and in the nomenclature adopted, it is extremely difficult to bring the several classifications into complete agreement. This difficulty is accentuated by the impossibility of being certain even that similar regions of the cortex have been described by the several authors, and by the probability that few, if any, of the descriptions in any sense represent the general average of systematic examination.

The first minute description of the layers of the cortex of the calcarine fissure was published by MEYNERT (26) in 1872, and the subdivisions he adopts only differ slightly from those I have made use of for the purposes of this research. MEYNERT'S layers are as follows :—

1. Molecular layer.
2. Layer of small pyramids.
3. Outer granule layer.
4. Layer of large pyramids and solitary cells.
5. Middle granule layer.
6. Analogue of 4.
7. Deep granule layer.
8. Layer of spindle-formed cells.

KRAUSE (27) in 1876 described this region of the cortex merely as a variety of ordinary "motor" cortex, and as consisting of the following layers :—

1. Tangential layer.
2. Molecular layer.
3. Layer of small pyramids.
4. Thick outer nerve plexus.
5. Layer of large pyramids.
6. Inner nerve plexus.
7. Layer of grains or small cells.

BETZ (28) in 1881 practically repeated MEYNERT'S classification describing the following layers :—

1. Molecular layer.
2. Layer of small pyramids.
3. First layer of granules.
4. Layer of nerve fibres.
5. Second layer of granules.
6. ,, nerve fibres.
7. Layer of isolated pyramids.
8. ,, spindle cells.

LEONOVA (29) in 1893 described the structure of the normal calcarine cortex in a new born infant as follows :—

1. Ependyma layer.
2. Layer of thickly-packed neuroblasts.
3. Layer of less closely-packed neuroblasts.

4. Pale stripe.
5. Layer of dense granules.
6. „ BAILLARGER (outer).
7. Intermediate layer of BAILLARGER.
8. Line of BAILLARGER (inner).

LEONOVA's paper will be referred to later on in connection with the visual area in anophthalmos.

HAMMARBERG (25) in 1895, in a posthumous paper published by HENSCHEN, described and figured numerous regions of the cortex cerebri, and amongst others that of the "gyrus occipitalis superior." In this convolution he enumerated eight layers with a total thickness of 2·38 millims. They are as follows :—

1. 0·12 millim. molecular layer.
2. 0·38 „ layer of small pyramids.
3. 0·19 „ „ small, large, and mixed cells.
4. 0·13 „ „ medium scattered cells.
5. 0·23 „ „ small granules.
6. 0·24 „ „ scattered and solitary cells.
7. 0·55 „ „ irregular cells.
8. 0·54 „ „ fusiform cells.

SCHLAPP (23) in 1898 described in the occipital region of the monkey, the following eight layers :—

1. Tangential layer.
2. Layer of outer polymorphic cells.
3. „ pyramidal cells.
4. „ granules.
5. „ small solitary cells.
6. Second layer of granules.
7. Layer poor in cells.
8. Layer of inner polymorphic cells.

Finally, CAJAL (24) has recently published (1900) in the first section of his "Hirnrinde des Menschen," an elaborate description of the "Seh-rinde" or calcarine cortex, which he is of opinion is found in the cuneus and the calcarine fissure, but not elsewhere in the occipital lobe, it being thus limited to the inner flat surface of the hinder part of the brain. He describes the following nine layers :—

1. First plexiform layer.
2. Layer of small pyramids.
3. „ middle-sized pyramids.

4. Second plexiform layer.
5. Layer of small granules.
6. ,, ,, elongated cells.
7. Third plexiform layer.
8. Layer of close-crowded medium pyramids.
9. ,, spindle-formed cells.

In my examination of the "occipital" cortex, which has included the cutting into small blocks, and the subsequent sectioning of the whole of six occipital lobes, I have found, I think, the key to a correct description of the "calcarine" or "occipital" cortex, in the abrupt change in structure which takes place at the periphery of the area of special lamination which I shall describe in a later section of this paper. I do not deny that further subdivisions of the different layers I describe can be made, but the classification I have adopted is probably a rational basis for the further study of this most important subject, and the layers about to be described are, in my experience, the only ones that can be made use of for the accurate micrometer measurements which I have found it necessary to make and analyse during the present investigation. The subdivision into layers which I have adopted is as follows :—

A. *Calcarine or Visuo-sensory Cortex:*

1. Outer layer of nerve fibres.
2. Layer of small pyramids.
3*a*. Outer layer of granules containing pyramids.
3*b*. Middle layer of nerve fibres or line of GENNARI, containing the solitary cells of MEYNERT.
3*c*. Inner layer of granules.
4. Inner layer of nerve fibres, containing the solitary cells of MEYNERT.
5. Layer of polymorphic cells.

B. *Neighbouring or Visuo-psychic Cortex:*

1. Outer layer of nerve fibres.
2. Layer of small and large pyramids.
3. ,, granules containing pyramids.
4. Inner layer of nerve fibres.
5. Layer of polymorphic cells.

It will be noticed that in this subdivision of layers no note is taken of the fusiform cells described by other authors. I have two reasons for neglecting these. In the first place they only occur at or near the apex of a convolution, and in some cases in a less degree on the flat surface, and in the second, as I have seen numerous

perfectly vertical sections through an apex in which they are entirely absent, I am disposed to think that if they exist as a true layer at all, it is only in very abrupt apices, and that very probably they only appear owing to the section missing the exact core of the apex, and so including scattered cells which really belong to the polymorphic layer of the cortex immediately adjacent to the apex of the convolution.

Fig. 4 (Plate 9), taken from one of the preparations from which section 13, in fig. 27 of Case 2 has been prepared, gives a good general idea of a cross-section of the calcarine fissure, and of the extent to which the special lamination extends laterally above and below the lips of the fissure in this region. It also illustrates the four regions of a convolution available for micrometer measurements. I have named these "side," "apex," "bottom," and "flat surface" respectively. The "sides" of a convolution are the parts in contact between the surface of the brain and the bottom of a fissure; the "apex" is the point at which an abrupt twist takes place, this being usually at the lips of the fissure but occasionally, in the case of narrow convolutions, on the surface of the brain; the "bottom" represents the bottom of a fissure; and the "flat surface" represents the cortex on the surface of the brain between two apices or fissure lips. Whilst the terms used are perhaps open to objection, these four regions are in my experience the only parts of a convolution capable of accurate micrometer measurement.

At the change in lamination above referred to, the line of GENNARI or layer $3b$ abruptly ceases, and the layers of granules $3a$ and $3c$ run together and abruptly become a single layer of approximately the thickness of the previous layer $3a$. This appearance is well seen in fig. 5, Plate 9, and fig. 6, Plate 10, which are respectively prepared from the upper or left-hand side of fig. 19, section 13 (p, 191), and from the apex in the middle of fig. 19, section 21 (p. 191), both of Case 1.

Fig. 5 is a microphotograph of a Nissl preparation, and clearly shows the running together of the two layers of granules to form a single layer. In this preparation all the layers of the cortex are visible. Fig. 6 is a composite microphotograph, prepared from Nissl and Weigert-Pal preparations of serial sections. It shows both the nerve cells and the nerve fibres, and clearly demonstrates the position of the line of GENNARI between the two granule layers, and also its abrupt termination at the change in lamination. Only layers 1, 2, and 3 a, b, c are illustrated in this preparation. By the microphotograph in fig. 7, Plate 10, is illustrated the general appearance of a section of visuo-sensory cortex. This illustration is purposely chosen to represent the intermediate appearances which exist between the apical or flat and the side sections of the cortex. It is prepared from the lower or right-hand half of section 17 in figs. 15, 17, and 19. By comparing this microphotograph with the previous ones it will be at once seen how much less clearly defined are the various layers, and how difficult and unsatisfactory micrometer measurement would be in this case. This fact would be much more obvious were a wider strip of cortex depicted in the illustration.

Exactly the same layers can be described and measured in sections of the cortex of infants, where the line of GENNARI exists as in adults, although, owing to non-development of the neurones concerned in its structure, it is difficult or impossible to prepare even moderately satisfactory Weigert-Pal preparations. The line of GENNARI also exists in anophthalmos, as may be seen by examination of the micro-photographs in Plate 11, figs. 9, 8, and 10, which are respectively taken from the apex and from either side of the left or lower lip of the calcarine fissure in section 8 in Case 6, figs. 44 and 45. In illustrations 10 and 8 the various layers of the visuo-sensory and the visuo-psychic cortices respectively are depicted, and at the left side of illustration 9 the abrupt change from the one to the other lamination can be readily made out. These photographs are necessarily imperfect, as it is by no means easy to obtain a section capable of being photographed in three separate regions in such a manner as to clearly bring out the required features. These photographs, and especially the area mapped out in figs. 43, 44, and 45 of Case 6, entirely dispose of the statement made by LEONOVA that the line of GENNARI is absent in anophthalmos and congenital atrophy of the globes of the eyes. The explanation of LEONOVA's statement can also be readily seen by reference to figs. 43 and 44, and to the sections in fig. 45, for these illustrations show that the visual area in this case does not occupy the usual position but is limited to a part only of this, viz., to the lower lip of the stem and of the anterior part of the body of the calcarine fissure, together with the anterior part of the lingual lobule. Hence LEONOVA, who prepared the sections described in the paper just referred to from some part of the calcarine fissure not clearly indicated, probably entirely missed the area of special lamination, and so described the ordinary visuo-psychic cortex in anophthalmos as visuo-sensory.

I have attempted in the following table (fig. 11) to group together the different classifications of "occipital" or "calcarine" cortex to which I have previously referred. It will be seen that my own classification agrees exactly with those of MEYNERT and BETZ, except in the absence of a scattered spindle layer, which omission I have already alluded to (pp. 184–185), and in the fact that the layer which I speak of as "polymorphic," is described by MEYNERT as consisting of deep granules, and by BETZ as being composed of isolated pyramids. It also agrees with that of SCHLAPP, except in the detail that he subdivides layer 2 into two parts. KRAUSE subdivides layer 1, and groups layers 2 and $3a$ as his third layer. Both LEONOVA and CAJAL subdivide layers 2 and $3a$ differently from other writers, as they do not recognise as a separate entity the important outer granule layer and CAJAL also recognises the spindle layer of cells. HAMMARBERG also figures the spindle layer, but includes in his third layer half of the line of GENNARI.

(The basis used for describing the depth of the different layers in the table is the general average of the measurements taken from Case 1, and stated in Table I., fig. 49, (p. 212), and Table III., fig. 51 (p. 216). It of course does not correspond with

the measurements, apparently made from an apex, which are given by HAMMARBERG, in his illustration of the gyrus occipitalis superior.)

Fig. 11.

TABLE SHOWING THE RELATION TO ONE ANOTHER OF THE VARIOUS PUBLISHED CLASSIFICATIONS OF "OCCIPITAL" LAMINATION.

YEAR.	1872.	1876.	1881.	1893.	1895.	1898.	1900.	YEAR.
OBSERVER	MEYNERT.	KRAUSE.	BETZ.	LEONOVA.	HAMMARBERG	SCHLAPP.	CAJAL.	OBSERVER
1.	1	1 / 2	1	1	1	1	1	*1.*
2.	2	3	2	2 / 3	2	2 / 3	2 / 3	*2.*
3a.	3	3	3	3	3	4	3	*3a.*
3b.	4	4	4	4	3 / 4	5	4	*3b.*
3c.	5	5	5	5	5	6	5	*3c.*
4.	6	6	6	6	6	7	6 / 7	*4.*
5.	7	7	7	7	7	8	8	*5.*
	8		8		8		9	

The horizontal lines in this table represent the subdivisions of the cortex adopted by the author. The numbers of the various layers are placed on either side.

KRAUSE'S subdivision of the molecular layer is undoubtedly correct, but it enters too much into minutiæ for the purposes of general micrometer measurement. LEONOVA'S subdivision of layers 2 and $3a$ is perfectly comprehensible if it be remembered that in all young brains the superficial pyramids are much more closely packed together than in later life, and so can almost be separated as a distinct layer. He does not, however, recognise the outer granule layer. HAMMARBERG'S inclusion of solitary cells in layer 3 is difficult to understand, except on the ground that he worked with Nissl preparations, and would consequently not notice that this portion of the cortex belonged to the line of GENNARI. There may, however, be an error in the reproduction

of his drawing. CAJAL's subdivision of layers 2 and $3a$, and of layer 4 into two parts, is in all probability perfectly correct from the point of view of special cell form, but it is not possible to define these layers from the point of view of micrometer measurements. He, however, whilst he figures the outer granules in the lower part of his layer 3 (*loc. cit.*, p. 9, fig. 1), does not recognise them as a separate entity in his classification. My reasons for adopting the outer granules as a distinct layer are (1) that the layer is a well-marked feature of the cortex and is easy to measure, and (2) that at the periphery of the visuo-sensory area the two layers of granules run into one.

SECTION 4.

The present section contains a description of the six occipital lobes which have been made use of during this investigation.

The cases are as follows :—

(1) J. A., aged 55 years. Brain normal. Cause of death, pneumonia.
(2) L. C., aged 17 years. A case of chronic insanity. Cause of death, pericarditis and pleuro-pneumonia, following rheumatic fever.
(3) M. A. B., aged 27 years. A case of chronic insanity with blindness from infancy. Cause of death, pulmonary tuberculosis.
(4) J. E. W., aged 30 years. A case of chronic insanity with long-standing blindness. Cause of death, pulmonary tuberculosis.
(5) W. J. V., aged 3 months. Brain normal. Cause of death, broncho-pneumonia.
(6) A case of anophthalmos, aged 1 month. Cause of death, marasmus.

Case 1.

J. A. Age 55 years. Died April 14, 1897.

History.—A previously healthy man, who died in hospital of right lobar pneumonia.

Case 1.

Illustrations 12 to 19 give in themselves an almost sufficiently full account of the distribution of the visuo-sensory area in the different parts of the calcarine fissure. In figs. 12, 14, and 16 the superficial distribution of the area is mapped out on the outer, inner and inferior aspects of the brain. It will be seen from these that the area occupies the whole of the body of the calcarine fissure extending above to the parallel cuneal sulcus and below to the collateral fissure. It occupies the posterior part of the calcarine fissure, extending round the pole to the outer surface of the hemisphere to a considerable extent, being surrounded at its postero-external extremity by well defined sulci. Anteriorly it extends along the lower lip of the stem of the calcarine fissure almost to its anterior extremity. The various sulci

mapped out in these figures have been carefully verified and names are attached to the chief fissures and convolutions. No names are attached to these or any other of the figures where there exists any possible doubt as to the nomenclature which should be adopted. Figs. 13, 15, and 17 are duplicates of those already referred to and are introduced in order to show clearly the exact regions from which the sections

Fig. 12.

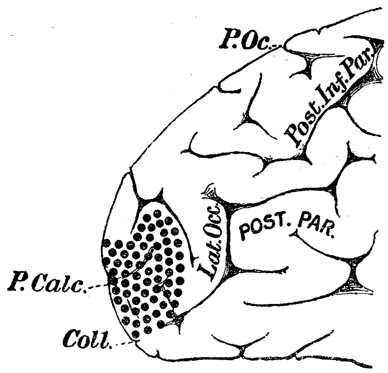


Fig. 13.

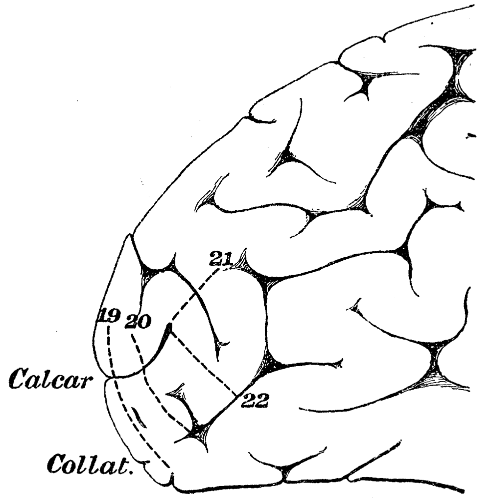


Fig. 14.

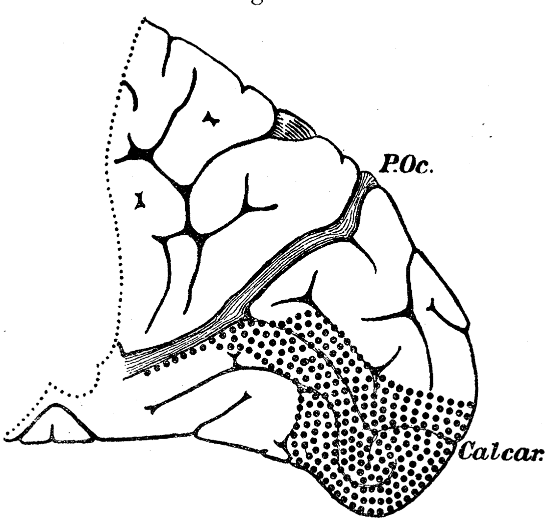
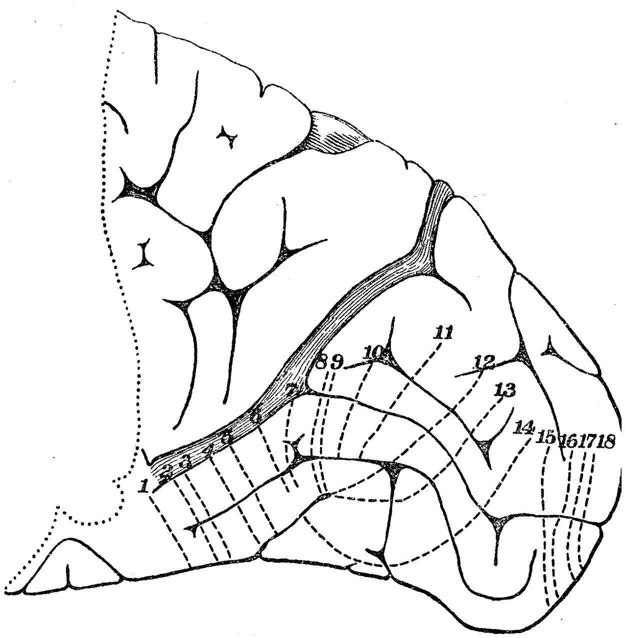


Fig. 15.



in figs. 18 and 19 have been prepared. The numbers on these figures in each case correspond with those attached to the various sections. The sections were prepared by combining together tracings taken directly from microscopic preparations of the regions in which they occurred, and they are consequently of the natural size.

Fig. 16.

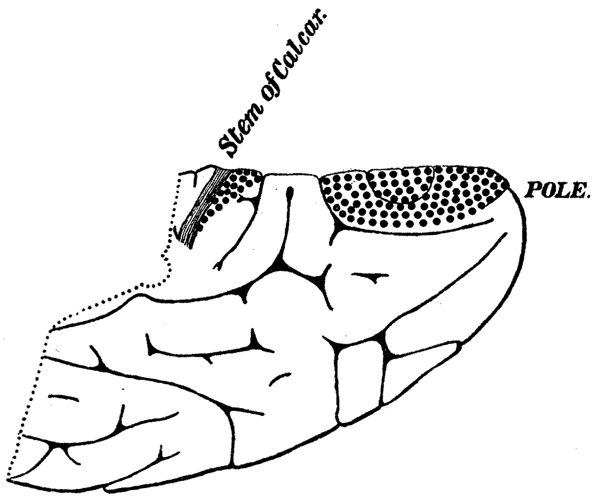


Fig. 17.

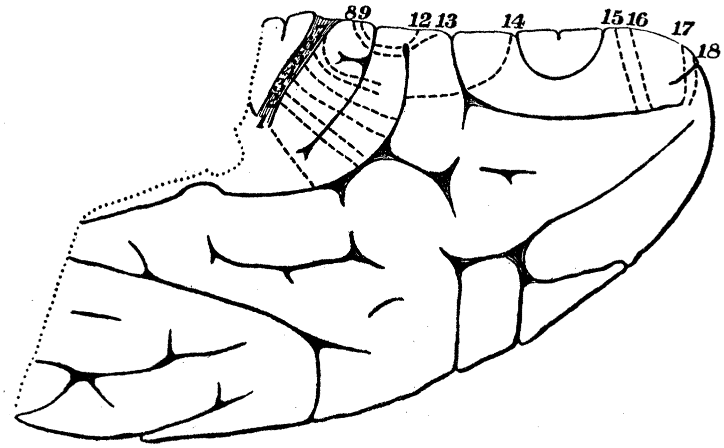
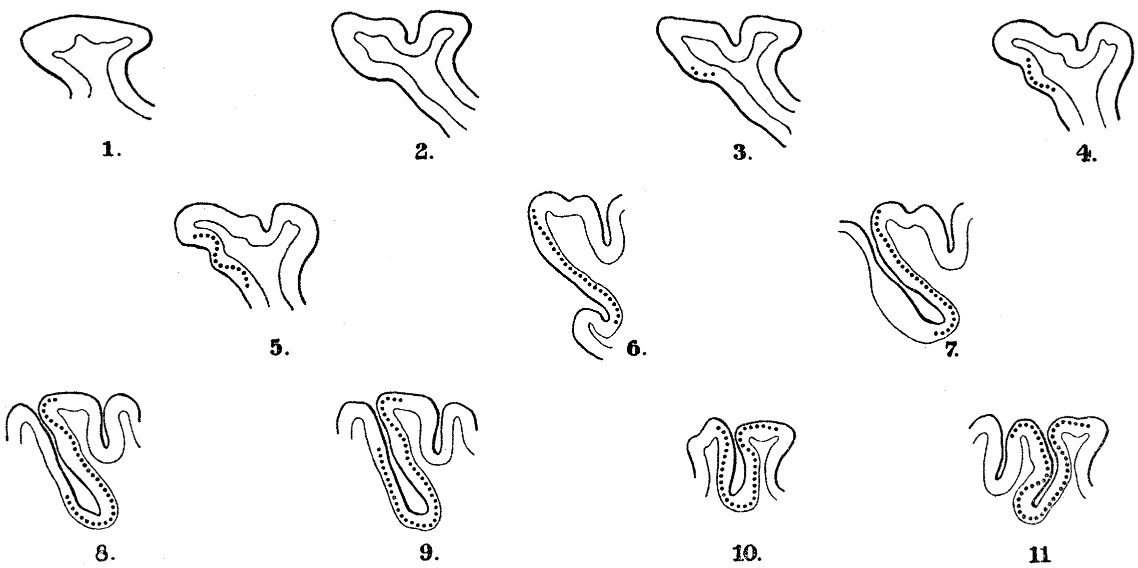
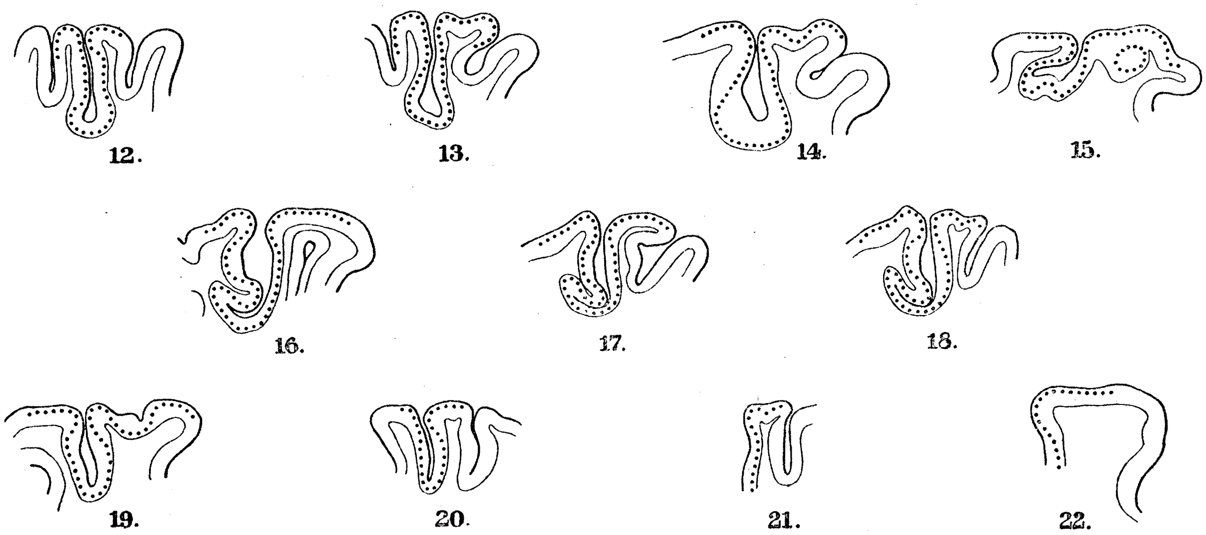


Fig. 18.



In figs. 18, 19, 26, 27, 32, and 39 the left side of the sections corresponds to the portion above the calcarine fissure, and the right to the part below. In figs. 42 and 45 the sections, being made in the opposite hemisphere, lie the other way round.

Fig. 19.



Sections 1 and 2 are taken from the anterior part of the stem of the calcarine fissure, and are in front of the termination of the area of special lamination. They indicate the anteriorly decreasing depth of the stem at this point. In section 3 it will be seen that the special lamination is beginning as a point, and in section 4 it is more extended and appears as a definite projection on the lower lip of the stem of the calcarine fissure. At the left side of sections 6 and 7 may be seen the cuneal annectant, which in this brain is of small size and in the portion of the stem between these two sections rises rapidly to the surface of the brain instead of ascending gradually into the apex of the cuneus, as occurs in the cases of some of the brains to be described later. In sections 8 and 9 it will be seen that the special lamination has not yet risen to the surface of the brain. This region, however, is in CUNNINGHAM'S description still a portion of the stem of the calcarine fissure. In section 10 it will be seen that the fissure is by no means so deep and this section and the following one give representations of the anterior cuneo-lingual annectant, and of the beginning of the body of the calcarine fissure. The special lamination has here reached upwards across the upper lip of the calcarine fissure as far as the parallel cuneal sulcus. Sections 12 and 13 through the middle of the body of the calcarine fissure demonstrate a somewhat increased depth of this portion of the sulcus. In sections 14 to 18 are seen various cross sections of the posterior cuneo-lingual annectant, which is particularly large and complex in this brain. Section 19 taken just outside the pole of the hemisphere shows a slightly decreased depth of the sulcus with, however, a persistence of the superficial extent of the special lamination. In various specimens of the region of section 20 the lamination is seen to occupy the area indicated in fig. 12, though as seen in section 20 it does not enter into the depth of the irregular little sulcus which here projects upwards from the posterior extremity of the lateral occipital fissure towards the end of the calcarine

sulcus. Finally, sections 21 and 22, which extend radially from the tip of the calcarine fissure, demonstrate the limit of the special lamination in these regions.

All the sections of the present and the later cases lie in the particular planes given, as they are composed of smaller sections taken as accurately as possible at right angles to the course of the convolutions concerned. This has added greatly to the labour of the research, but has been absolutely necessary for the purposes of micrometer measurement. If the posterior portion of a hemisphere be cut into coronal sections, it at once becomes evident how remarkably few regions are at right angles to the course of the convolutions. In fact almost the only micrometer measurements which could be obtained would be taken from the flat external surfaces or the bottoms of the fissures.

Case 2.

L. C. Female. Admitted December 5, 1895. Age $15\frac{1}{2}$ years. Died March 20th, 1897.

History.—Father is described as dissipated. One cousin is an epileptic and another was a patient in this asylum some years ago. Both these cousins were females on the father's side. For four years before admission the patient had occasional fits at regular intervals. Two weeks before admission she became confused in manner and conversation, careless in habits and very erotic. She was excited and noisy after the fits. She was in domestic service before becoming insane. On admission she was rather anæmic, but otherwise healthy. Mentally she was dull, sullen, and irritable, and had several ordinary epileptic fits shortly after admission. She rapidly improved and became bright and rational. She was sent home on trial in February, 1896, having had no fits for over six weeks. Two months later she returned to the asylum in the same condition as on her previous admission, and with frequent fits. She again improved and the fits ceased in about a month. In August, 1896, she had a severe attack of tonsillitis, and in September an attack of acute rheumatism, which was followed by permanent mitral disease. She had subsequently several slight rheumatic attacks and the fits returned to the extent of about one a week owing to anti-epileptic treatment not being persisted in. Her mental state deteriorated and she became silly, childish, and emotional, and had considerable loss of memory, In February, 1897, she had a further attack of tonsillitis, with marked pericarditis, and recovered fairly rapidly, but a month later died, after five days of acute illness of the same nature, with, in addition, pleuro-pneumonia. The temperature before death was 109° F. The post-mortem examination showed the existence of old and recent pericarditis and endocarditis, and of recent pleuro-pneumonia.

It will at once be seen on comparison of figs. 20, 22, and 24, with figs. 12, 14, and 16 of the previous case, that the surface distribution of the visuo-sensory area in Case 2 occupies exactly the same region in relation to the calcarine fissure as in Case 1. There is, however, a marked difference in the general position and

characters of the area in the two brains, but this is seen at a glance to be due to differences in the direction and complexity of the respective calcarine fissures. In Case 2 the area passes below rather than round the pole, and barely extends to the outer surface of the hemisphere. Sections 1 to 20, in figs. 26 and 27, taken across the

Fig. 20.

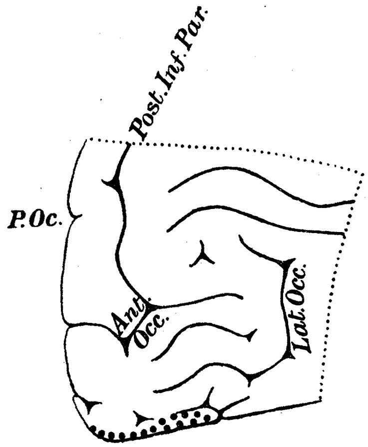


Fig. 21.

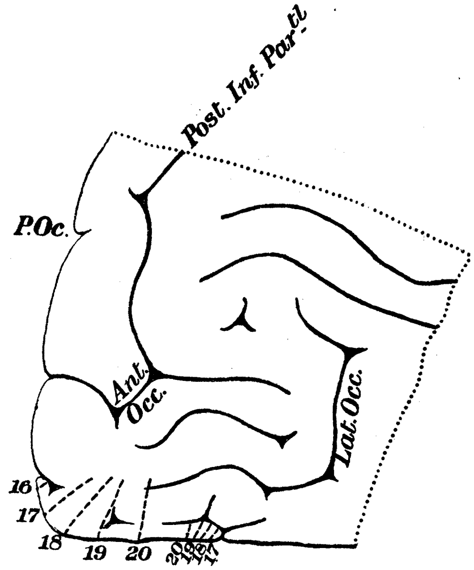


Fig. 22.

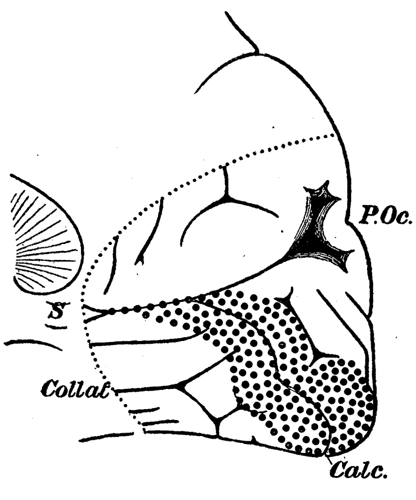
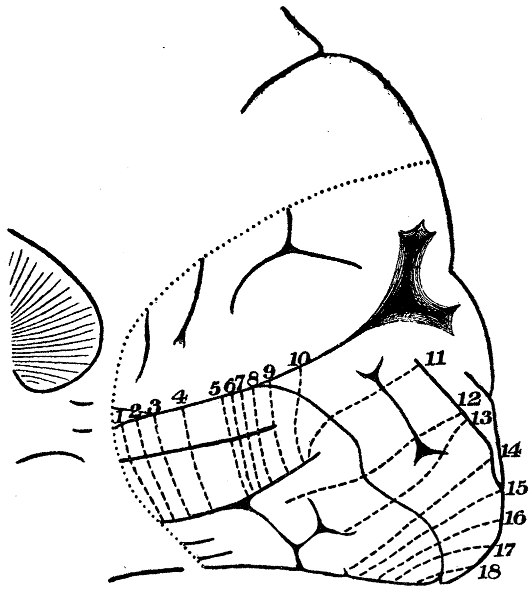


Fig. 23.



calcarine fissure, give on comparison with figs. 21, 23, and 25, a good general idea of the appearance of the sulcus in its different parts. Sections 1 and 2 lying anterior to the special lamination show that in this region the fissure is deeper than in the case of the previous brain, although as before it decreases in depth anteriorly. In

sections 3 and 4, the projection of the commencing area of special lamination on the lower lip of the stem of the calcarine fissure is well shown. Sections 5 to 9 demonstrate the large size of the cuneal annectant in this brain, and also that it ends anteriorly by joining the lower lip of the stem of the calcarine fissure instead of, as is the more usual, ending in the upper one. They also show how owing to this the

Fig. 24.

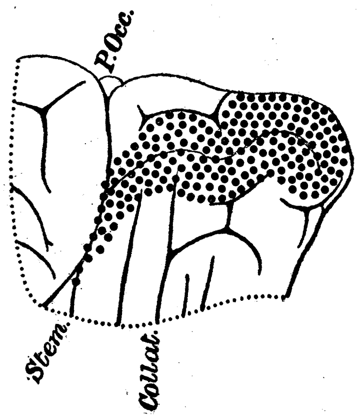


Fig. 25.

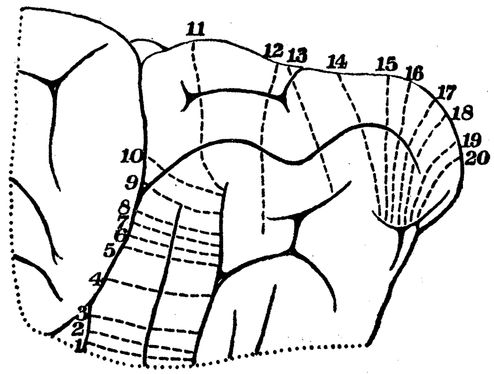
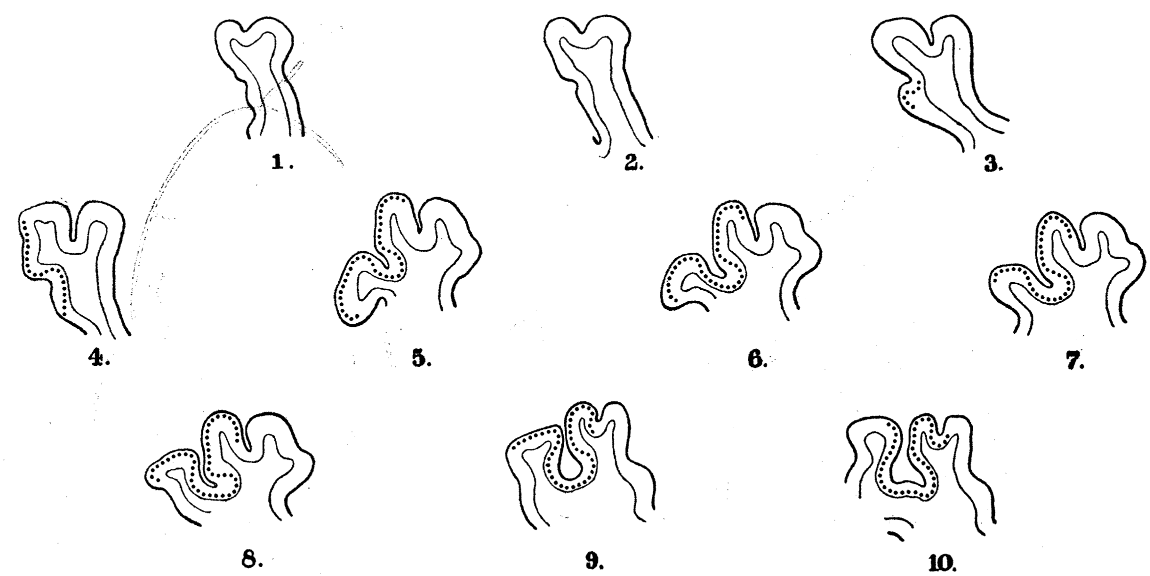


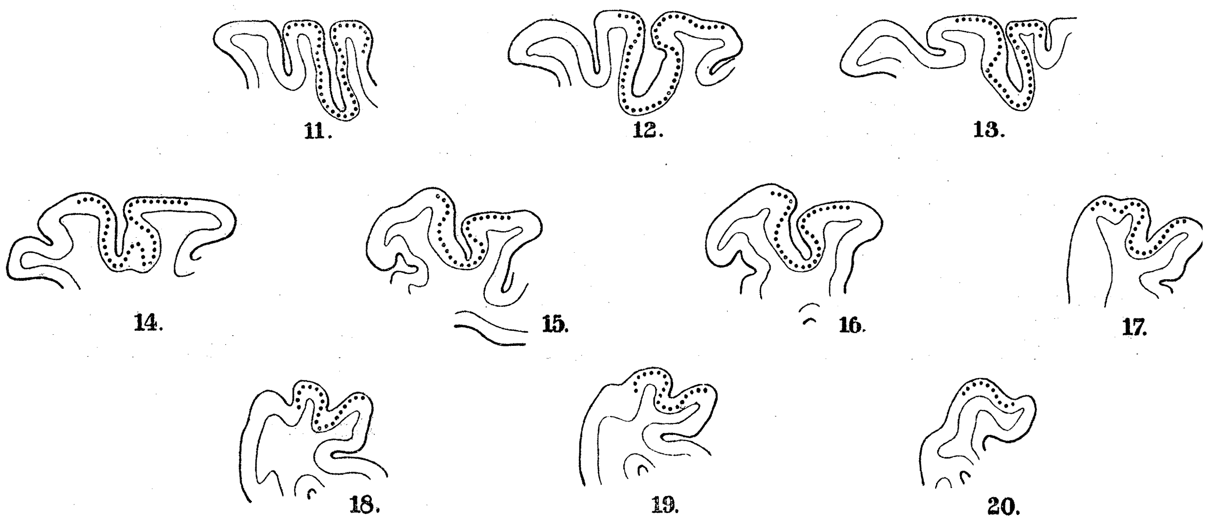
Fig. 26.



floor of the calcarine fissure is raised gradually to the position shown in section 10, which represents the region of the anterior cuneo-lingual annectant and the beginning of the body ot the fissure, in quite a different manner from that in the previous case. It will be seen also from these sections that the area of special lamination occupies the superficial and the lower surfaces of this annectant. Sections 11

and 12 give a representation of the body of the calcarine fissure and, as in the previous case, show a relatively increased depth of the fissure in this part of its course. As in the previous case also the special lamination extends upwards to the parallel cuneal sulcus and downwards to the, in this case somewhat irregular, collateral fissure. In sections 13 and 14 the posterior cuneo-lingual annectant may be seen. It will be

Fig. 27.



noticed that this annectant is much smaller and less complex than in the previous case. In sections 15 to 19 the gradually decreasing depth of the fissure towards its termination, again without any abbreviation of the superficial extent of the special lamination, is shown; and in section 20 taken beyond the tip of the fissure, the area is decreased in width and later on, as is shown by serial sections of this region, it ends bluntly, as is mapped out in figs. 20, 22, and 24.

Case 3.

M. A. B. Female. Admitted December 2nd, 1891, age 22 years. Died November 14th, 1896.

History.—Mother, a low drunken prostitute. The patient was found when an infant in a cellar by the visiting teacher of a blind asylum. She was then blind in the right eye, but could distinguish objects from a blank space in a strong light by means of the left eye. This gradually projected, became painful, and was enucleated. The attack of insanity began by depression and alteration in behaviour associated with a falling off in physical health. A month before admission she began to hear voices. She had always been hot tempered and reserved in disposition and generally wanting in control, though she was affectionate to her friends. She had "growing pains" seven or eight years before admission, and had since that time suffered from shortness of breath. On admission patient was in delicate health. The

right pupil was occluded by a thick leucoma, and the left eyeball was absent. She had a presystolic thrill at the apex, which was diffuse and not heaving in character, and there was epigastric and episternal pulsation. The mitral first sound was impure and the second pulmonary sound loud. There was occasionally a harsh rub at the base of the heart (exocardial). Mentally she was in a condition of clinical "mania" and had hallucinations of hearing and delusions of poisoning. In November, 1893, she was in a condition of chronic insanity, was incoherent, and had delusions concerning electricity and also auditory hallucinations. During the next few years her condition was unchanged, and she spent her time walking about with uplifted face and conversing with imaginary people, whose voices she apparently heard. This condition lasted till the autumn of 1896, when she developed an acute attack of pulmonary tuberculosis, of which she died on the 14th November.

A comparison of figs. 28 and 30 with the corresponding illustrations of the previous cases shows a marked diminution of the superficial extent of the area mapped out, and this is, if anything, more marked above than below the calcarine fissure. It would be still more obvious also were it not for an unfolding of the stem of the

Fig. 28.

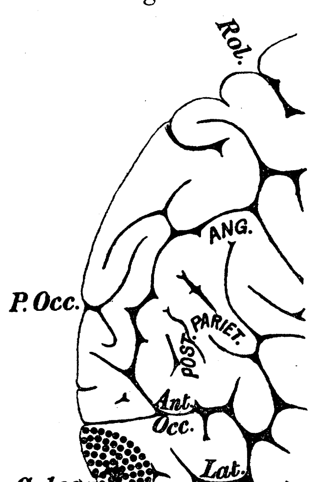
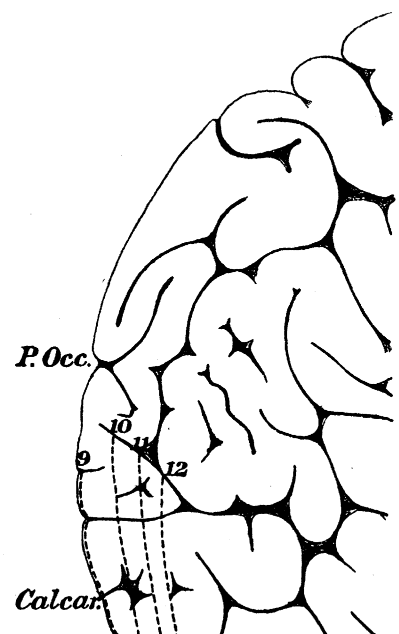


Fig. 29.



fissure, which exposes the area in this region more than is the case in the other brains. Sections 1 to 12 in fig. 32 show that this diminution also occurs in the interior of the fissure, as is evident from its much decreased depth. In section 1 is seen the anterior end of the stem of the calcarine fissure in front of the special lamination, and

in sections 2 and 3 the tip of the area is shown. These sections, when compared with the corresponding sections of the previous cases (figs. 18 and 19 and 26 and 27), demonstrate a markedly decreased depth of the stem of the calcarine fissure in this part of the course. Sections 4 and 5 show the appearance and development of the

Fig. 30.

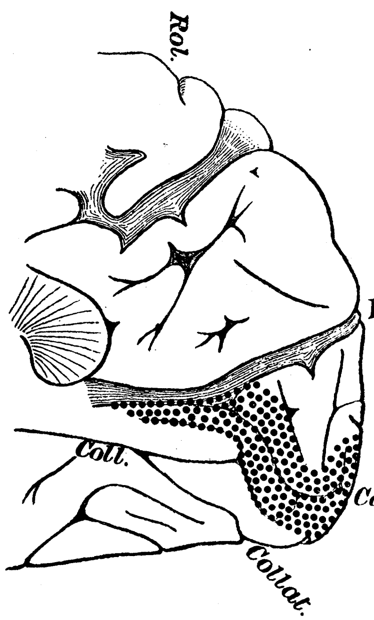


Fig. 31.

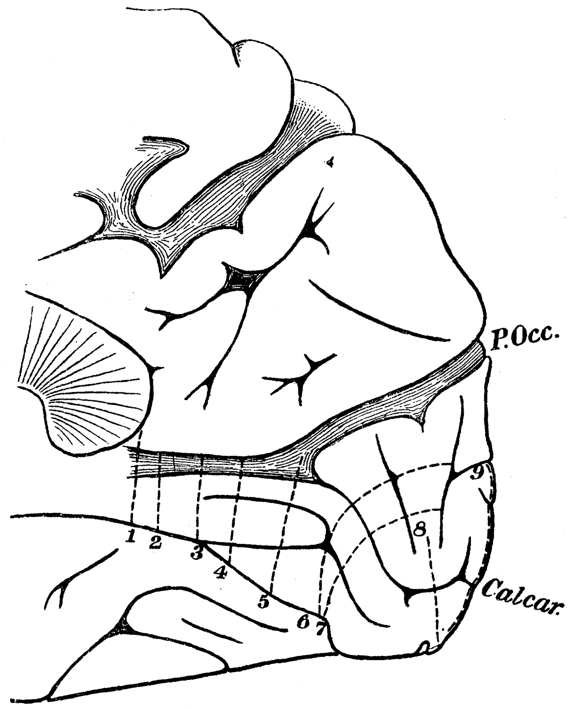
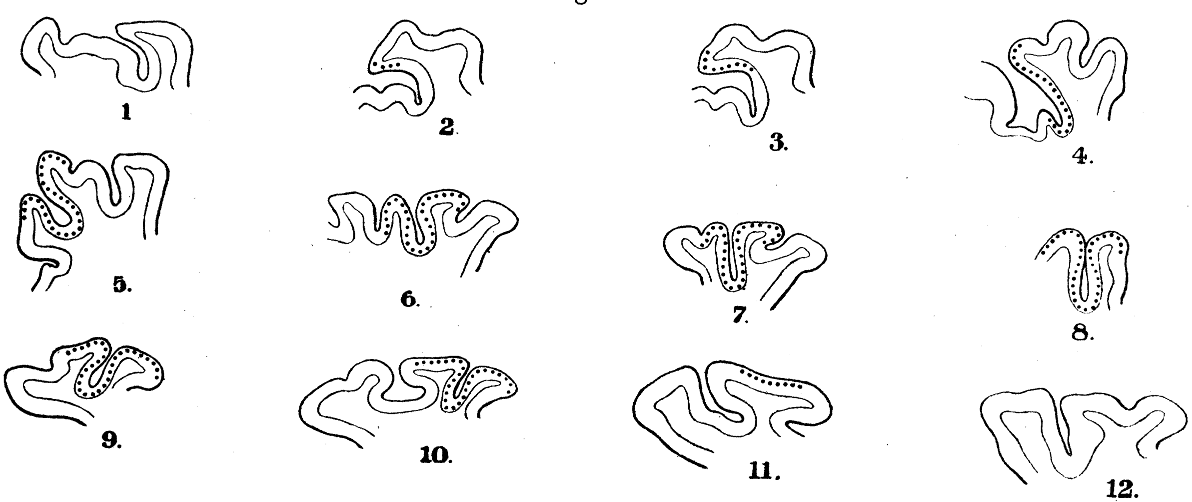


Fig. 32.



cuneal annectant, which, though smaller, resembles that in Case 2. In section 6 a decreased depth of the sulcus is the only indication of the presence of the anterior cuneo-lingual annectant and the beginning of the body of the calcarine fissure. The

special lamination extends above to the parallel cuneal sulcus, and below to the sub-fissure of the collateral sulcus illustrated in the figures, and these gyri, as well as the calcarine fissure, are much smaller than the corresponding ones of the previous cases. A similar statement may be made of the condition of these parts in section 7, which is taken across the middle of the calcarine fissure, and in section 8, which passes across the region of the posterior cuneo-lingual annectant. This annectant, however, like the anterior, is invisible. Sections 9 and 10 show a decreased depth of the calcarine fissure towards its posterior extremity without any corresponding decrease in the superficial extent of the special lamination. Section 11 shows the extent of the lamination beyond the tip of the calcarine fissure, and serial sections from this region to that figured in section 12 demonstrate the blunt ending of the lamination which is shown in fig. 28. Taken as a whole, the figures illustrating this case show a well-marked decrease in the depth of the calcarine fissure, in the size of the neighbouring sulci, and in the superficial extent of the area of special lamination. These conditions, apart from the micrometer measurements to be given in the next Section, are in themselves of great importance as regards the determination of the functions of this region of the brain. As regards the decreased depth of the fissure and the diminution in size of the surrounding sulci, this brain and the one in the succeeding case confirm the observations of HENSCHEN and other authors, who have described marked atrophy of the calcarine fissure and neighbouring parts in cases of long-standing blindness.

Case 4.

J. E. W., male. Admitted April 6th, 1898. Aged 29 years. Died January 28th 1899.

History.—On admission was in good physical health. The globes of both eyes were extremely wasted, the right more than the left, and the patient was absolutely blind. No history of the duration of this condition could be obtained, but the patient had for many years earned his living as a blind musician. Mentally he was suffering from clinical "mania," but soon became fairly sensible, and was, as far as his blindness allowed, a willing worker. Shortly before his death he developed some degree of dementia. He contracted pulmonary tuberculosis in the autumn of 1898, and died on the 28th January, 1899. The post-mortem examination showed the existence of exquisite bilateral optic atrophy of both the nerves and tracts. The pia-arachnoid was slightly thickened, and there was some frontal atrophy. The lungs showed the usual signs of tuberculosis.

In this case a decrease in the superficial extent of the area of special lamination, even more marked than in Case 2, exists, as will be seen on comparison of figs. 33, 35, and 37 with the corresponding illustrations of the preceding cases. On the other hand, the decrease in the depth and complexity of the calcarine fissure shown in fig. 39, sections 1 to 15, is less marked than in Case 3, though very obvious in

comparison with Cases 1 and 2. Sections 1 and 2, like those of the previous cases, show the decreasing depth of the stem of the calcarine fissure anterior to the area of special lamination. In sections 3 and 4 is seen the prominence which

Fig. 33.

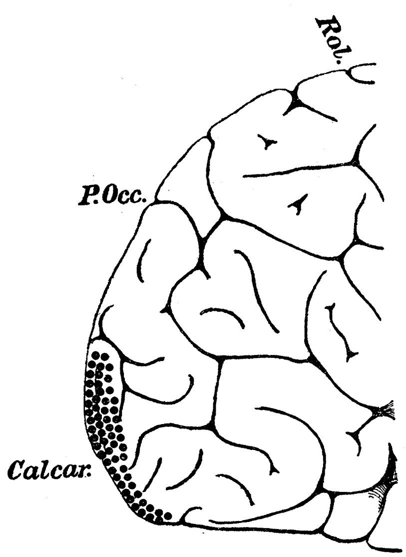


Fig. 34.

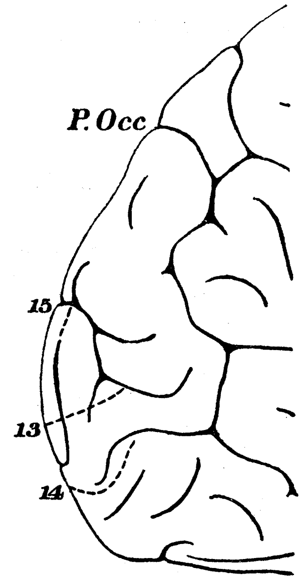


Fig. 35.

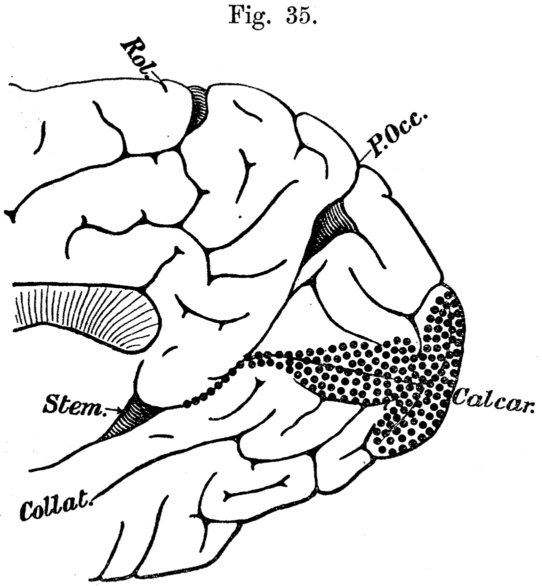
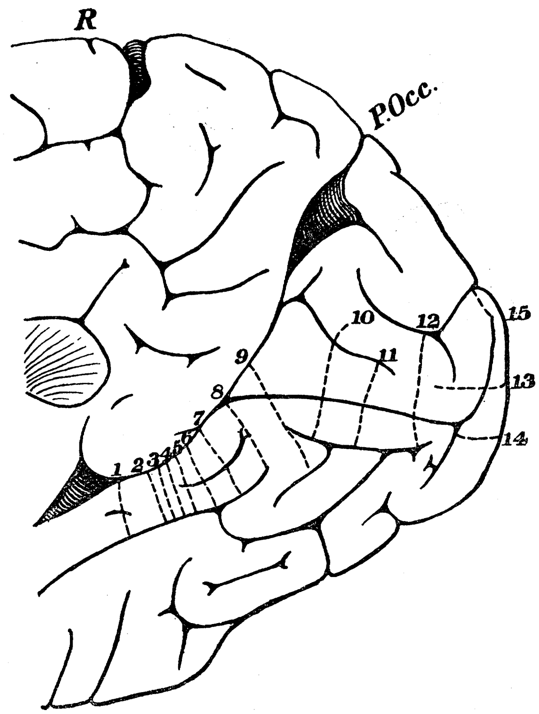


Fig. 36.



occurs at the tip of the area, and section 4 also shows the beginning of the cuneal annectant, which here arises from the upper lip of the stem, and the further develop-

ment of which is figured in sections 5 to 9. The latter sections also demonstrate that the special lamination occupies the lower surface of this annectant, but not the superficial portion which it occupies in Case 2. In section 10 is figured the anterior cuneo-lingual annectant, which is well marked in this brain, and in section 11 is seen the relatively decreased depth of the middle of the calcarine fissure. Section 11 also shows that in this region the special lamination barely reaches to the parallel

Fig. 37.

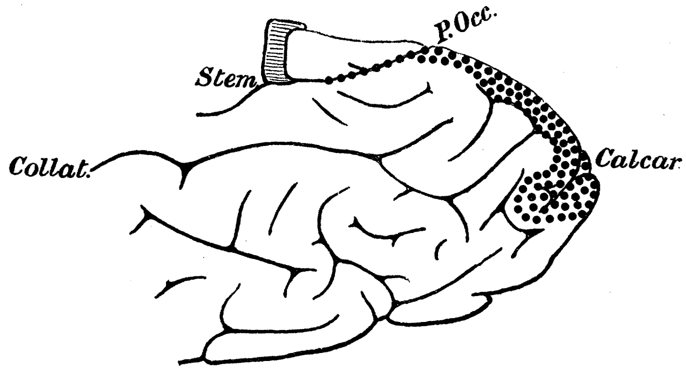


Fig. 38.

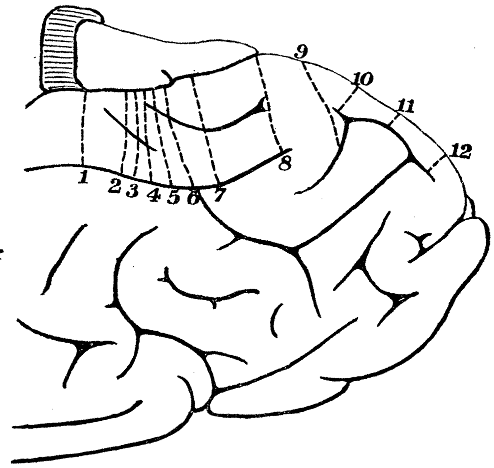
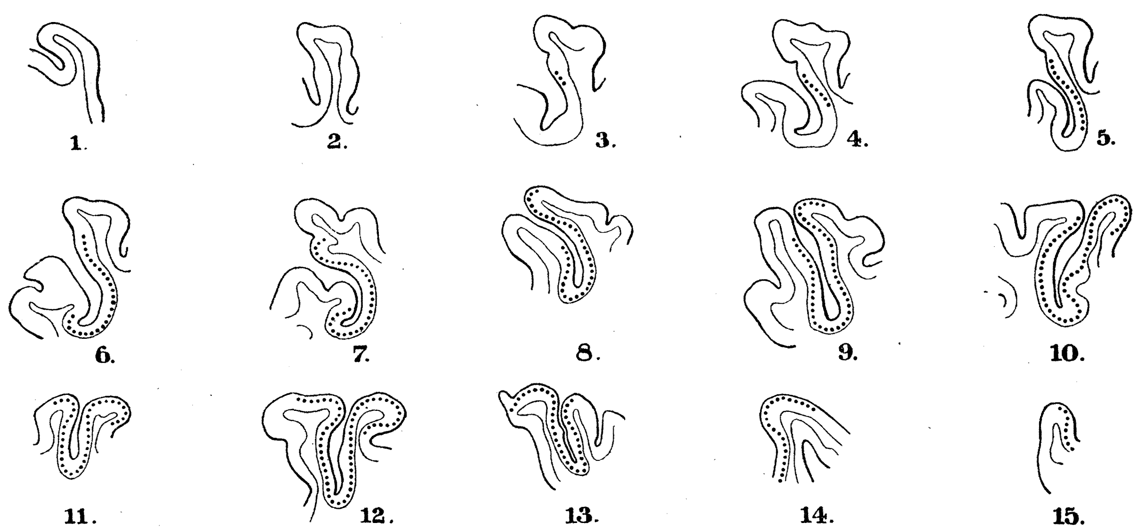


Fig. 39.



cuneal sulcus. In section 12 the posterior cuneo-lingual annectant is well marked, and in section 13 is seen the relatively slight extension of the special lamination on either side of the upper limb of the calcarine fissure. Finally, section 14 shows how far the special lamination extends behind the bifurcation of the calcarine fissure, and section 15 demonstrates the same point as regards the tip of the upper subdivision of the sulcus, and also shows the decreased depth of the fissure in this region. The

extent of the special lamination round the lower limb of the calcarine fissure is illustrated in figs. 35 and 37. In Case 4, taken as a whole, may be seen the same decrease in the depth of the calcarine fissure, in the size of the neighbouring sulci, and particularly in the superficial extent of the area of special lamination, to which attention has already been drawn in Case 3.

Case 5.

W. J. V., male. Born on Jubilee Day, 1897. Died three months later.

History.—A perfectly healthy infant, who died at the age of three months from broncho-pneumonia.

The illustrations of this case show, in the opposite hemisphere to that figured in the previous cases, the normal limitations of the area of special lamination in the infant. A comparison of figs. 40, 41, and 42 with the corresponding illustrations of

Fig. 40.

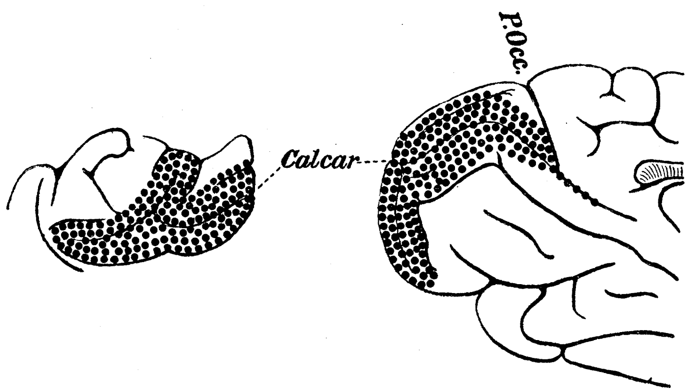
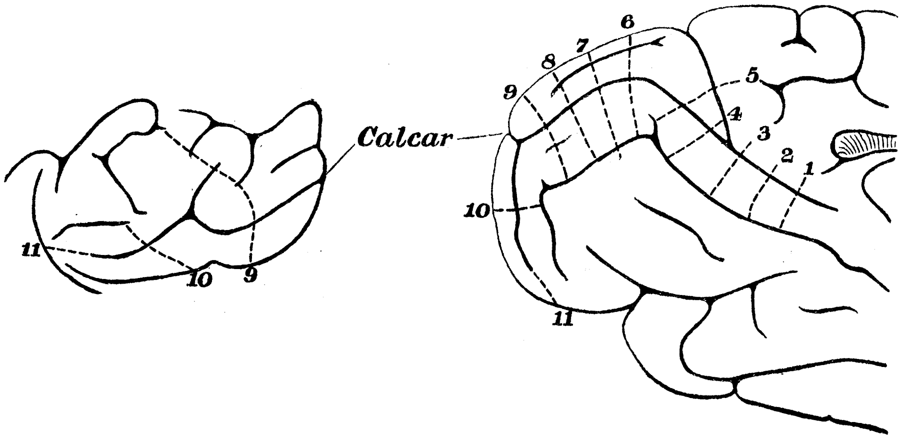


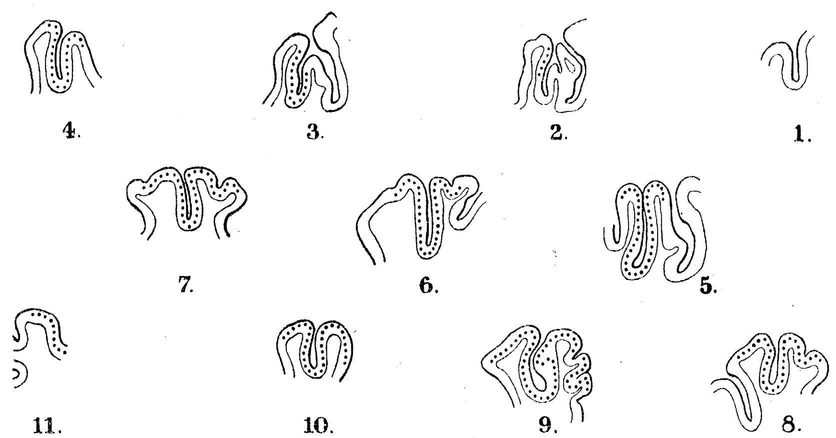
Fig. 41.



Cases 1 and 2, demonstrates that the area is identical in distribution with that described in these brains. It occupies the body of the calcarine fissure and the neighbouring cortex, extending above to and just beyond the parallel cuneal sulcus,

and below to the collateral fissure; the posterior extremity of the calcarine fissure and the neighbouring cortex as far as the polar sulci surrounding its extremities; and the lower lip of the stem of the calcarine fissure, towards the anterior end of which it tails off to a point. These details are clearly shown in figs. 40 and 41 and in fig. 42, sections 1 to 11. In section 1 is seen the relatively slight depth of the stem of the calcarine fissure in front of the special lamination, and in section 2 the tip of the area. In sections 2, 3, and 4 is figured the cuneal annectant, and in the last two of these the special lamination occupies the lower surface, and in section 4 the superficial surface of this annectant. Section 5 shows, by the depth rather than the complexity of the sulcus, the region of the anterior cuneo-lingual annectant, and sections 6 and 7 that of the middle of the calcarine fissure, which here has a relatively decreased depth. In sections 8 and 9 is seen the region of the posterior cuneo-

Fig. 42.



lingual annectant, which is fairly well marked in this brain. Section 9 also extends across the upper limb of the calcarine fissure to the external surface of the hemisphere, and shows the superficial extent of the lamination in this region. Section 10 is taken across the lower limb of the calcarine fissure, and section 11 from the termination of the lower limb to the polar sulcus. Both these, but especially the latter, illustrate the decreased depth of the fissure in this region.

It may perhaps be worth while to draw attention here to the fact that in the series of sections in Cases 5 and 6, owing to the use of the left hemisphere in place of the right, the right side of the sections in each case corresponds to the portion above the calcarine fissure, and the left to that below, whereas in the case of the other illustrations the left side of the section corresponds to the part above the calcarine fissure, and the right to the part below.

Case 6.

Anophthalmos. Died at the age of one month on April 19th, 1897.

History.—This infant was born of healthy parents and died of marasmus at the

age of one month. The post-mortem was made forty-eight hours after death, in a small country cottage. The orbits were chink-like, and contained a little yellowish tissue at the back, which was apparently composed of fat. The eyelids were represented by small slits. No trace of either optic nerves or eyeballs could be discovered.

An examination of figs. 43 and 44 and of the sections in fig. 45 demonstrates the remarkable contraction of the area of special lamination which exists in anophthal-

Fig. 43.

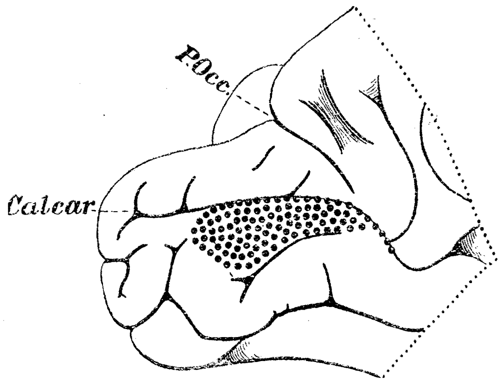


Fig. 44.

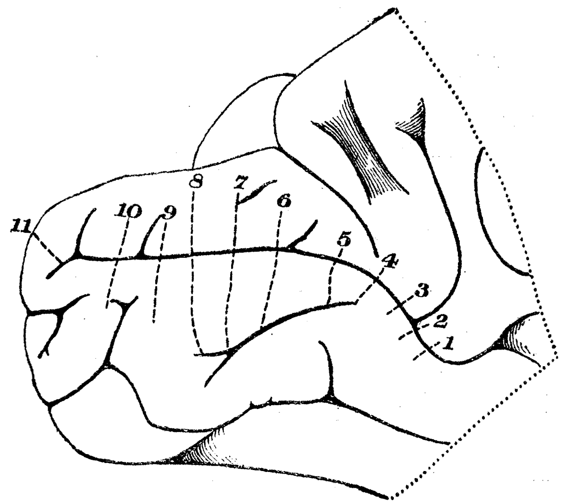
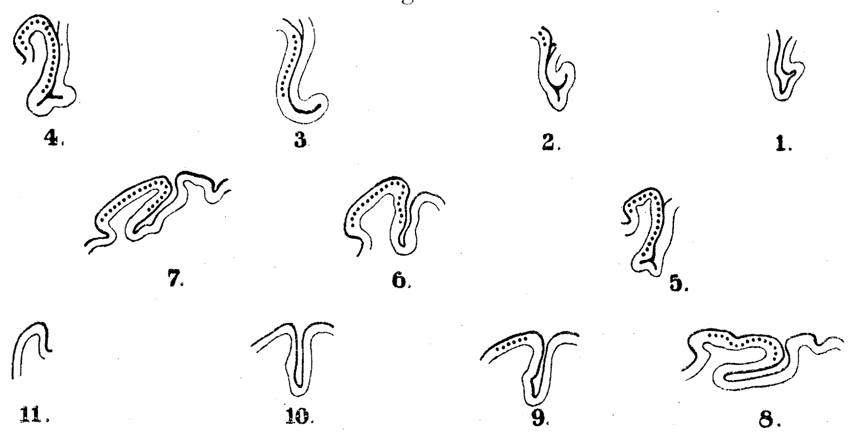


Fig. 45.



mos. It will be seen from these illustrations that the area occupies the usual position in the stem of the calcarine fissure, but only extends backwards for rather more than half the length of the body of this sulcus, the posterior extremity of the area extending to the posterior cuneo-lingual annectant. It is also confined to the lower lip of the calcarine fissure, and to the anterior portion of the lingual lobule. In section 1, fig. 45, is seen the relatively superficial appearance of the stem of the calcarine fissure anterior to the special lamination, and in section 2, which shows the

tip of the area, the depth of the stem below the surface is very little greater. In section 3 the special lamination has extended somewhat, and the depth of the sulcus has much increased. The cuneal annectant, being superficial (see figs. 43 and 44), is not represented in sections 4 and 5, and as seen in section 6 the anterior cuneo-lingual annectant is rudimentary. Sections 7 and 8, through the middle of the calcarine fissure, show how this sulcus pockets downwards underneath the lingual lobule in this part of its course without, however, the special lamination on the lower lip extending down to the deeper part of the sulcus. In section 9 may be seen the rudimentary posterior cuneo-lingual annectant, and also the termination of the area of special lamination on the cortex of the lingual lobule. In section 10 the special lamination is absent, but the posterior cuneo-lingual annectant is still visible. Finally, section 11 shows the decreased depth of the calcarine fissure at its lower extremity.

The rudimentary condition of the area of special lamination in this case is very interesting in view of the opinion expressed by BRISSAUD, that the visuo-sensory area lies below the calcarine fissure. The fact also, that this area in its rudimentary condition still occupies the lower lip of the stem of the calcarine fissure is of importance, owing to the statement made on developmental grounds by CUNNINGHAM, that the "stem" of the calcarine fissure belongs to the calcarine sulcus and not to the parieto-occipital.

From a survey of the six cases which have been described the following conclusions may be drawn :—

1. The "occipital" lamination in the region of the calcarine fissure is a well defined cortical area.

2. The general distribution of this area is as follows. It occupies :—

(a) The body of the calcarine fissure, including the anterior and posterior annectants, and extending upwards to the parallel cuneal sulcus and downwards to the collateral fissure.

(b) The posterior part of the calcarine fissure, extending to the polar sulci surrounding its extremities.

(c) The inferior lip of the stem of the calcarine fissure, including the superficial surface and lower lip of the cuneal annectant, nearly to its anterior extremity, just posterior to which the area tails off to a sharp point.

3. The approximate outline of this area is consequently pear-shaped, with the apex anteriorly and the thick end at the pole of the hemisphere.

4. The area is much decreased in extent, but not in distribution in cases of long-standing blindness.

5. The area is much contracted in anophthalmos as regards both extent and distribution. It occupies the usual position in the stem of the calcarine fissure, but only extends backwards as far as the posterior cuneo-lingual annectant, and it is

confined to a portion of the inferior lip of the fissure and to the cortex between this and the collateral sulcus.

SECTION 5.

In this section the methods made use of during the present investigation are briefly described. Of the 6 brains which have been examined, the first 4 were hardened in 5 per cent. formalin, the 1st, 2nd, and 4th without stripping, and the 3rd after stripping. The stripping of the last brain in the fresh state probably explained the unfolding of the stem and the relatively increased superficial extent of the area of special lamination compared with that in Case 4, which is really in a less marked condition than Case 3. The other brains were carefully stripped after hardening. Whilst in some respects the stripping of the brain was a disadvantage, as it rendered relatively valueless the micrometer measurements of the outer layer of nerve fibres, it was absolutely essential for the accurate localisation purposes of the present investigation. Even if complete stripping had been avoidable, a considerable amount of pia-arachnoid would have necessarily been torn away during the removal of the different blocks of tissue. In the case of the 5th and 6th brains the hardening, owing to the softness of the tissue, was completed in a mixture of alcohol and formalin, the brains being finally removed to 5 per cent. formalin before use.

This method, owing to the primary fixing in formalin solution and to the subsequent use of alcohol to coagulate the tissue, avoided the marked shrinking of the brains which would otherwise have occurred. These brains, owing to the thinness of the pia-arachnoid, were not stripped, but during the necessary manipulations the greater part of the membrane invariably became separated.

The brains were then carefully drawn from different aspects as nearly as possible of the natural size, and in the case of the last three with the assistance of life-size photographs. The drawings were afterwards corrected, as further examination, and especially the cutting out of blocks of tissue, exposed inaccuracies. These were so relatively frequent as clearly to show how difficult it is to obtain an accurate knowledge of the course and depth of the sulci of the cerebral cortex from surface examination only.

The whole of the regions under investigation were then carefully separated into blocks, which were invariably cut in such a manner and of such a size as to enable sections to be made from them at right angles to the course of the gyri without more waste of tissue than was absolutely unavoidable. The blocks were all carefully numbered, and sketches of both surfaces were made for future orientation.

In the case of the 3rd brain, which was the first to be worked out, 69 blocks were made, and of these 26 were omitted. 16 blocks containing visuo-psychic cortex only, and 27 containing both visuo-psychic and visuo-sensory cortices, making 43 in all, were used for micrometer measurements.

In the case of the 2nd brain, which was the next to be worked out, 45 blocks were

cut, and of these 11 were omitted. 10 blocks containing visuo-psychic cortex only, and 24 containing both the laminations, or 34 in all, were made use of.

From the 1st brain, 41 blocks were cut, and it was necessary to omit 2 only, 5 blocks containing visuo-psychic cortex, and 34 containing both laminations, or 39 in all, being used.

The blocks omitted in these cases were those which extended more than about $\frac{1}{2}$ an inch beyond the area of special lamination, and the omissions were made in order that the tissue used in all the cases might be the same. It is probably owing to the care which was exercised in the selection of sections from these three brains, in order to obtain an almost theoretical correspondence of the areas examined and compared, that the averaged micrometer measurements in these three cases show such a number of remarkable coincidences.

In the case of the 4th brain, 39 blocks were prepared, and of these 34 contained both laminations, 4 the visuo-psychic only, and 1 the visuo-sensory only. From the 5th brain, 20 blocks were removed, of which 19 contain both laminations, and 1 the visuo-sensory only. The smaller number of blocks in this case is of course due to the smaller size of the lobe examined.

Finally, from the 6th brain, 20 blocks were again cut, and of these 11 contained both laminations, and 9 the visuo-psychic lamination only. The large number of regions containing visuo-psychic lamination only is here due to the small development of the area of special lamination.

The greater number of the blocks were cut by the freezing method, which is probably responsible for the fact that not a single error of orientation occurred throughout the investigation. The sections were consequently cut, stained, mounted, and drawn before their different appearances had been forgotten. After being cut, the sections were prepared by the Nissl method, and by one or other of the modifications of the Weigert-Pal method, which I have described in previous papers (30). In the case of a certain number of the more important blocks the paraffin method was used, and the sections were stained by the Nissl, or by a modification of the Weigert-iron method, a 2 per cent. solution of iron-alum being substituted for the tinct. ferri perchloridi usually employed. The latter method was largely used in the case of brains 5 and 6, as the soft tissue of which they were composed did not lend itself readily to the freezing method.

The sections were then traced by means of a camera obscura, in order to form the larger sections reproduced in the different figures.

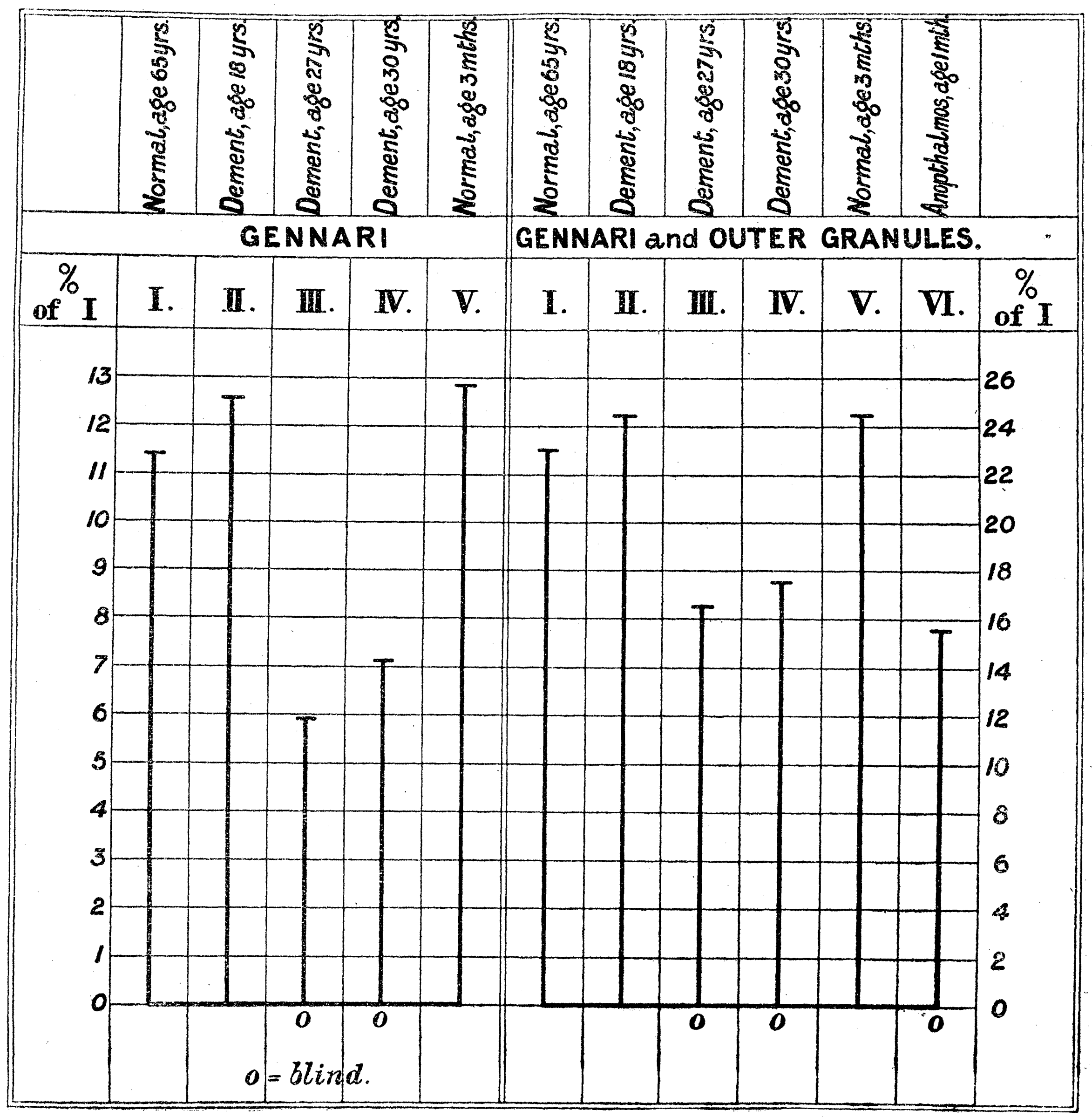
The micrometer measurements were made by means of a Zeiss A objective and a No. 2 eye-piece with a tube of 160 millims., and they were then reduced to micro-millimetres by the constant (14·73) of this particular combination. The constant of course varies somewhat in the case of different lenses of the same manufacture.

SECTION 6.

In the tables at the end of this Section, figs. 49 to 52, I have given in full the micrometer measurements made from the cases described in Section 4 of this paper. A general summary in the form of a chart is, however, shown in fig. 46. In this it can be seen at a glance that in the two cases of long-standing blindness, aged respectively 27 and 30 years, the line of GENNARI is decreased to one-half of the thickness it possesses in the three other cases, which respectively show the conditions

Fig. 46.

VISUO-SENSORY CORTEX.



of this layer of the cortex in the man of 55 years, in an epileptic dement aged 18 years, and in an infant of 3 months. These latter cases afford a striking illustration of the relatively slight variation which exists in the thickness of this cortical layer at the different periods of life and even in chronic insanity. In the second half of the chart is shown the thinning, down to two-thirds of the normal, of the conjoined line of GENNARI and outer granule layer, in the two cases of old-standing blindness, and in the case of anophthalmos. As has been already referred to in section 3 (p. 185), the measurements (see Plate 9, fig. 4) have been made respectively through the *sides* or parts of the convolutions in contact in the fissures, the *apices* or fissure lips, the *bottoms* of the fissures, and the *flat* external surfaces of the convolutions. It has also been stated that these regions of the convolution are the only ones capable of accurate micrometer measurement.

In Tables I. and II., figs. 49 and 50, are given, in millims., the measurements of the visuo-sensory and visuo-psychic regions respectively in the six brains which have been examined, and in Tables III. and IV., figs. 51 and 52, these measurements have been reduced to percentages of Case 1.

In addition to the chief conclusions to which attention has been drawn many points of interest may be seen on careful examination of these tables. In Table III., fig. 51, the almost exact correspondence, allowing for the necessary errors of measurement, of the depth of the conjoined 4th and 5th layers is well shown, as is also the extreme atrophy of the line of GENNARI in the blind cases, and the considerable decrease of thickness of layer 3*a*. In Case 6, owing to the almost complete invisibility of the latter layer, layers 3*a* and 3*b* were measured together. On examination of layers 1 and 2 another important fact appears, viz., that there is an almost exact correspondence between the thickness of the conjoined 1st and 2nd layers of the cortex, and the degree of amentia or dementia existing in the patient. Case 1 is normal. Case 4 which showed a relatively slight degree of dementia approaches most nearly to the normal. Cases 5 and 6 of infants aged respectively three months and one month come next in order, and Cases 3 and 4 of pronounced chronic insanity with dementia, occupy the last place on the list. This is a point of considerable importance in view of the facts that the 4th and 5th layers show no constant variation, and that layer 3 as a whole is of the same thickness respectively in the three patients with normal vision, and in the three cases of blindness. In Table IV. (fig. 52), a similar relation is seen in the respective depth of the conjoined 1st and 2nd layers of the cortex in the different cases. Here, however, in the infants, and especially in the younger of the two, this layer is much thinner than in the cases of pronounced chronic insanity, on the other hand, in the first four cases on the list, the same relation exists as that shown in Table III. (fig. 51). This is probably to be explained by the non-development of the purely psychic regions of the cortex in infants as, owing to the fact that the afferent tracts develop before the efferent, it is not unreasonable to suppose that the psychic portion of the visuo-

sensory cortex would develop earlier than the corresponding region in the neighbouring purely psychic portion of the brain. In the cases of chronic insanity, on the other hand, the same relation should, and does, exist as regards the respective depth of the conjoined first two layers in both regions of the cortex. From the measurements of layers 4 and 5 in Table IV. (fig. 52), no conclusions can be drawn in spite of the considerable difference in the depth of these layers in the first three and last three cases respectively.

A more minute analysis of the measurements in Case 1 in Tables I. and II. (figs. 49 and 50), brings forward certain considerations of importance as regards the depth of the different layers of the cortex in the several regions of the convolutions. The same facts may be seen on examination of the figures derived from the other cases, but they are of less importance owing to the existence of important modifying factors, *e.g.*, in the infants, non-development of the adult structure; and in the cases of chronic insanity, thickening of the membranes associated with wasting, especially of the superficial portions of the convolutions and of the lips of the fissures. The relative thicknesses of the different layers in the visuo-sensory and visuo-psychic cortices respectively of Case 1 are seen in the following tables (figs. 47 and 48), in which the relative thicknesses of the layers in the several regions are compared with the layers of the sides of the convolutions.

Fig. 47.

VISUO-SENSORY CORTEX.

TABLE I.

LAYERS.	1.	2.	3. a.	3. b.	3. c.	4.	5.
SIDE.	1·0	1·0	1·0	1·0	1·0	1·0	1·0
APEX.	1·0	·9+	1·0	1·1	1·1+	1·6	1·5+
BOTTOM.	1·2	·8+	·9	·7	·7+	·5	·7
FLAT.	1·1	1·1	1·1	1·3	1·1	1·5	1·3
TOTAL.	4·3	3·9	4·0	4·1	4·0	4·6	4·5
AVERAGE.	1·08	·96	1·0	1·03	1·0	1·15	1·13
	1·1	1·0	1·0	1·0	1·0	1·2	1·1

Fig. 48.

VISUO-PSYCHIC CORTEX.

TABLE II.

LAYERS.	1.	2.	3.	4.	5.
SIDE.	1·0	1·0	1·0	1·0	1·0
APEX.	·9	·9	1·1	2·2	1·7
BOTTOM.	1·3	·8	·8	·4	·7
FLAT.	1·0	1·0	1·1	1·6	1·5
TOTAL.	4·2	3·7	4·0	5·2	4·9
AVERAGE.	1·1	·9	1·0	1·3	1·2

These tables show that the general average thickness in the case of the visuo-sensory lamination differs relatively little from that of the sides of the convolution. This condition, which is perfectly obvious during the examination of sections, for the superficial foldings of the convolutions, especially at the apices, are much less abrupt than is the case in the visuo-psychic region of the cortex, is probably due to the denser structure of the visuo-sensory region, owing to the sheaf of fibres from the optic radiations which passes to the neighbourhood of the line of GENNARI. In the case of the visuo-psychic cortex, on the other hand, the correspondence of the general average with that of the side measurements is much less marked.

On examination of these tables (figs. 47 and 48), and especially of the second, it will be seen that at the apices of the convolutions the first and second layers are decreased, the third is slightly increased, the fourth is more than doubled, and the fifth is much increased. This condition of the lower three layers exists to a less marked extent on the flat external surface. At the bottom of the fissures, on the other hand, whilst the first layer is increased, all the others, and especially the fourth, are decreased. This condition can be partly explained by the folding of the grey matter, for, at the apices, the convex outer surface would from this cause be relatively more extended and the layers consequently be thinned, whilst on the contrary the inner layers would be much increased in depth, this condition being intensified by the radiating manner in which the corticipetal and corticifugal fibres would necessarily have to pass in order to reach the convex surface. Owing to this radiation of fibres some slight thickening should also occur in the third layer, which would otherwise show little or no change in depth. On the other hand, at the bottom of the fissure the superficial layer would necessarily be thickened owing to

the large mass of fibres it would have to contain in spite of the relatively abrupt bend, and for the same reason the deeper layers will be thinned, partly owing to their occupying a relatively large convex area compared with the abrupt bend of the superficial layers, and partly to the relatively fewer number of corticipetal and corticifugal fibres which would require to pass through their convex extension of surface. If to this be added the fact that the surface convexity is necessarily larger in extent than the sharp bend at the bottom of the sulci, owing to the fact that fibres have to pass to and from all the surface parts of the cortex, and that the larger the external portion becomes the more acute must be the bend at the bottom of the fissure, probably the explanation given may be considered as entirely satisfactory a one as any that can be advanced.

That the explanation given is probably correct is seen on examination of the table in fig. 47, for in the visuo-sensory area it is certain that many more fibres pass to the cortex than is the case in the visuo-psychic region illustrated in the table in fig. 48. It is at once evident by comparing the figures of the two tables that the thinning of the layers at the bottoms of the fissures in the visuo-sensory cortex is relatively much more marked than is the alteration in depth of the various layers of the apices and flat surfaces; in other words, the bend at the bottom of the fissures is relatively more abrupt in the visuo-sensory cortex than it is in the visuo-psychic.

Whilst this matter is one of interest rather than importance, and may appear to be self-evident, it has, however, been thought desirable to refer to it here, as the facts are so clearly brought out by a study of the micrometer measurements introduced into this section. If the facts be considered self-evident, the discussion has probably been not without value as an illustration of the general accuracy of the measurements.

From the subject matter in this section the following conclusions may be drawn—

(1) In the area of special lamination described in Section 4, in cases of old standing optic atrophy, the line of GENNARI is decreased nearly 50 per cent. in thickness, and the outer granule layer more than 10 per cent.

(2) In the visuo-psychic region surrounding the area of special lamination, old standing optic atrophy causes no modification of the lamination.

(3) In anophthalmos the conjoined outer granule layer and line of GENNARI (for the granules in the former layer are not sufficiently obvious to admit of easy micrometer measurement alone), are narrowed down to two-thirds of the normal thickness, the other layers of the cortex being approximately unchanged. This amount of narrowing is the same as that found in cases of old standing optic atrophy.

(4) The majority of the layers of the cortex do not vary appreciably in thickness as a result of age or chronic insanity, but there is an almost exact correspondence between the thickness of the conjoined 1st and 2nd layers of the cortex, and the degree of amentia or dementia existing in the patient.

Fig. 49.

TABLE I.—VISUO-SENSORY CORTEX.

	REGION OF CONVOLUTIONS	Number Examined	Layer 1.	Layer 2.	Layer 3*a*	Layer 3*b*	Layer 3*c*	Layer 4.	Layer 5.
CASE 1.	SIDE.	27	·23892	·53131	·21830	·21447	·29195	·12388	·21167
	APEX.	24	·23627	·50200	·21786	·23450	·31183	·19944	·32833
	BOTTOM.	10	·27987	·45516	·20327	·14141	·21948	·05892	·14435
	FLAT.	22	·26249	·60187	·23170	·27118	·33408	·18486	·27722
	TOTAL.	**83**	**1·01755**	**2·09034**	**·87113**	**·86156**	**1·15734**	**·56710**	**·96157**
	1·88166 General Average.		**·25439**	**·52259**	·21778	·21539	·28934	·14178	·24039
						·72251			
CASE 2.	SIDE.	16	·22552	·43542	·25498	·23759	·33702	·12152	·24864
	APEX.	14	·20931	·40714	·20828	·28296	·35661	·22625	·34188
	BOTTOM.	6	·24555	·38048	·19635	·15467	·19886	·05406	·18413
	FLAT.	14	·22625	·46827	·23877	·27560	·30300	·18413	·28517
	TOTAL.	**50**	**·90663**	**1·69131**	**·89838**	**·95082**	**1·19549**	**·58596**	**1·05982**
	1·82212 General Average.		**·22666**	**·42283**	·22460	·23771	·29887	·14649	·26496
						·76118			
CASE 3.	SIDE.	24	·24982	·43336	·20681	·12771	·28724	·10989	·23759
	APEX.	17	·21226	·38386	·19414	·11784	·29283	·14907	·32494
	BOTTOM.	2	·22095	·32406	·16940	·07365	·16940	·07365	·16203
	FLAT.	4	·25777	·44190	·22095	·12889	·33143	·14730	·27619
	TOTAL.	**47**	**·94080**	**1·5831**	**·79130**	**·44809**	**1·08090**	**·47991**	**1·00075**
	1·58125 General Average.		**·23520**	**·39580**	·19783	·11202	·27023	·11998	·25019
						·58008			

Fig. 49—(*continued*).

TABLE I.—VISUO-SENSORY CORTEX.

	REGION OF CONVOLUTIONS	Number Examined	Layer 1.	Layer 2.	Layer 3a.	Layer 3b.	Layer 3c.	Layer 4.	Layer 5.
CASE 4.	SIDE.	55	·26971	·45133	·20268	·15540	·31552	·10900	·18722
	APEX.	24	·22773	·38725	·18354	·14052	·32347	·19208	·29710
	BOTTOM.	7	·36398	·36398	·16836	·09678	·19355	·05465	·12417
	FLAT.	8	·26146	·47136	·21727	·15275	·33143	·16203	·26691
	TOTAL.	94	1·12288	1·67392	·77185	·54545	1·16397	·51776	·87540
	1·66780 General Average.		·28072	·41848	·19296	·13636	·29099	·12944	·21885
						·62031			
CASE 5.	SIDE.	17	·20268	·42452	·22699	·24599	·25218	·12476	·19576
	APEX.	14	·17043	·42923	·21359	·27678	·27457	·22095	·29033
	BOTTOM.	9	·31920	·36015	·18987	·17838	·17838	·06216	·12609
	FLAT.	7	·27781	·49876	·25247	·26308	·26514	·15791	·19782
	TOTAL.	47	·97012	1·71266	·88292	·96423	·97027	·56578	·81000
	1·71899 General Average.		·24253	·42816	·22073	·24106	·24257	·14144	·20250
						·70436			
CASE 6.	SIDE.	6	·17426	·46650	·28237		·24555	·18663	·22832
	APEX.	4	·13257	·46400	·35352		·26882	·29460	·29460
	BOTTOM.	1	·44190	·44190	·29460		·17676	·11784	·14730
	FLAT.	7	·13463	·44396	·25247		·19989	·18088	·19149
	TOTAL.	18	·88336	1·81636	1·18296		·89102	·77995	·86171
	1·60384 General Average.		·22084	·45409	·29574		·22276	·19499	·21542
						·51850			

Fig. 50.

TABLE II.—VISUO-PSYCHIC CORTEX.

	REGION OF CONVOLUTIONS	Number Examined	Layer 1.	Layer 2.	Layer 3.	Layer 4.	Layer 5.	Layers 1 & 2.	Layers 3, 4 & 5.
CASE 1.	SIDE.	36	·26514	·90914	·19974	·17720	·24260		
	APEX.	35	·23229	·86274	·21800	·38887	·40994		
	BOTTOM.	12	·34498	·73650	·16321	·06746	·16571		
	FLAT.	19	·25512	·94817	·22095	·28149	·35426		
	TOTAL.	**102**	**1·09753**	**3·45655**	**·80190**	**·91502**	**1·17251**		
	1·86089 General Average.		**·27438**	**·86414**	**·20048**	**·22876**	**·29313**	**1·13852**	**·72237**
CASE 2.	SIDE.	41	·25159	·81914	·21196	·15849	·25468		
	APEX.	29	·21226	·79748	·22905	·33319	·35853		
	BOTTOM.	20	·29843	·65549	·16424	·05966	·18192		
	FLAT.	27	·23023	·84020	·22095	·30285	·36383		
	TOTAL.	**117**	**·99251**	**3·11230**	**·82620**	**·85419**	**1·15896**		
	1·73605 General Average.		**·24813**	**·77808**	**·20655**	**·21355**	**·28974**	**1·02621**	**·70984**
	SIDE.	42	·25498	·83711	·22655	·14244	·27103		
CASE 3.	APEX.	26	·21535	·80279	·24525	·30712	·39373		
	BOTTOM.	15	·28974	·66771	·17485	·06967	·18265		
	FLAT.	11	·24098	·85699	·24098	·21020	·33879		
	TOTAL.	**94**	**1·00105**	**3·16460**	**·88763**	**·72943**	**1·18620**		
	1·74223 General Average.		**·25026**	**·79115**	**·22191**	**·18236**	**·29655**	**1·04141**	**·70082**

Fig. 50—(*continued*).

TABLE II.—VISUO-PSYCHIC CORTEX.

	Region of Convolutions	Number Examined	Layer 1.	Layer 2.	Layer 3.	Layer 4.	Layer 5.	Layers 1 & 2.	Layers 3, 4 & 5.
CASE 4.	SIDE.	35	·26897	·83283	·18516	·14435	·21049		
	APEX.	34	·22964	·78202	·19105	·32715	·35396		
	BOTTOM.	23	·40287	·66035	·13772	·07748	·14347		
	FLAT.	12	·25527	·79792	·19886	·22581	·28355		
	TOTAL.	**104**	**1·15675**	**3·07312**	**·71279**	**·77479**	**·99147**		
	1·67723 General Average.		**·28919**	**·76828**	**·17820**	**·19369**	**·24787**	**1·05747**	**·61976**
CASE 5.	SIDE.	18	·22920	·72089	·19311	·17838	·21432		
	APEX.	16	·17764	·69967	·20445	·36825	·29740		
	BOTTOM.	6	·32656	·49596	·14480	·06878	·14980		
	FLAT.	3	·23568	·78555	·22095	·23083	·23568		
	TOTAL.	**43**	**·96908**	**2·70207**	**·76331**	**·84624**	**·89720**		
	1·54448 General Average.		**·24227**	**·67552**	**·19083**	**·21156**	**·22430**	**·91779**	**·62669**
CASE 6.	SIDE.	11	·17941	·56372	·17146	·21285	·18751		
	APEX.	14	·16409	·56814	·18619	·43247	·29460		
	BOTTOM.	15	·30830	·49198	·13065	·12182	·12771		
	FLAT.	11	·12859	·49419	·16733	·25041	·22095		
	TOTAL.	**51**	**·78039**	**2·11803**	**·65563**	**1·01755**	**·83077**		
	1·35060 General Average.		**·19510**	**·52951**	**·16391**	**·25439**	**·20769**	**·72461**	**·62599**

Fig. 51.

TABLE III.—VISUO-SENSORY CORTEX.

LAYERS	1	2	3 a	3 b	3 c	4	5	Percentage of Case I.	General Details.
CASES	%	%	%	%	%	%	%		
I	13·5	27·8	11·6	11·4 ×	15·4	7·5	12·8		Normal. Age 65 yrs.
	41·3			38·4		20·3		100·0	
II	12·0	22·5	11·9	12·6 ×	15·9	7·8	14·1		Chr. insanity. Age 18 yrs.
	34·5			40·4		21·9		96·8	
V	12·9	22·8	11·7	12·8 ×	12·9	7·5	10·8		Normal. Age 3 months.
	35·7			37·4		18·3		91·4	
III Blind.	12·5	21·0	10·5	5·9 ×	14·4	6·4	13·3		Chr. insanity, blind from infancy. Age 27 yrs.
	33·5			30·8		20·7		84·0	
IV Blind.	14·9	22·2	10·3	7·2 ×	15·5	6·9	11·6		Chr. insanity, with old-standing blindness. Age 30 yrs.
	37·1			33·0		18·5		88·6	
VI Blind.	11·7	24·1	← 15·7 →		11·8	10·4	11·5		Anophthalmos. Age 1 mth.
	35·8			27·5		21·9		85·2	

× Line of Gennari.

Fig. 52.

TABLE IV.—VISUO-PSYCHIC CORTEX.

LAYERS.	1	2	3	4	5	Percentage of Case I.	General Details.
CASES.	%	%	%	%	%		
I	14·8	46·4	10·8	12·3	15·7		Normal. Age 65 yrs.
	61·2			38·8		100	
II	13·3	41·8	11·1	11·5	15·6		Chr. insanity. Age 18 yrs.
	55·1			38·2		93·3	
III	13·4	42·5	11·9	9·8	16·0		Chr. insanity, blind from infancy. Age 27 yrs.
	55·9			37·7		93·6	
IV	15·5	41·3	9·6	10·4	13·3		Chr. insanity, with old-standing blindness. Age 30 yrs.
	56·8			33·3		90·1	
V	13·0	36·3	10·2	11·4	12·1		Normal. Age 3 months.
	49·3			33·7		83·0	
VI	10·5	28·4	8·8	13·7	11·2		Anophthalmos. Age 1 mth.
	38·9			33·7		72·6	

SECTION 7.—*General Review and Summary.*

In Section 1 a general account has been given of the macroscopic anatomy of the occipital region of the cerebrum, with a special reference to the brains made use of during this research. A short description of the vascular supply of the visual area has been added. This is based primarily on an original investigation, though the writer had been anticipated in this part of the subject by MONAKOW, whose account he is able to confirm and supplement. Certain typical vascular lesions are referred to, and especially one in which, together with softening in the regions supplied by the parieto-occipital branch of the occipital artery and by its subdivision, the cuneal artery, there exists in the depth of the parieto-occipital fissure an intact portion of cortex. This could conceivably from its position in relation to the visual area described and figured in Section 4, enable a certain portion of the visual fields to exist in spite of the almost complete destruction of the visual area, and it presumably derives its blood supply from the middle cerebral artery.

In Section 2 is given a critical digest of the literature published on the subject of the visual area from the experimental, clinico-pathological, and developmental standpoints during the past forty years. Attention is drawn to the opinion held by HENSCHEN which limits the visual area to the cortex within the lips of the calcarine fissure, and which derives support from the embryological studies of FLECHSIG and the clinico-pathological researches of SEGUIN, VIALET, and others. The case of HUN and one of those reported by HENSCHEN are cited as of importance in the cortical localisation of the upper and lower quadrants of the visual fields. The hemiopic representation of the retinæ in the occipital lobes is considered proved, otherwise importance would have been attached to one of the cases of HENSCHEN, where after loss of one eye normal cells were found to be lying side by side with wasted and pigmented cells in both calcarine regions. A selection of the more typical of the published lesions is referred to in place of a list, which would be of an enormous length, of the published cases.

Section 3 contains a historical summary of the published work on the structure of the "occipital" cortex, and the various views referred to are classified in tabular form as variations of the view advanced by the author. Importance is attached to the absence of definite statements by previous writers as to the exact macroscopic regions from which the tissue made use of was removed, and as to the particular portions of the sections of the convolutions which were described. The author considers that the key to a correct description of the gross microscopic structure of the cortex in this region lies in a study of the abrupt change in lamination which takes place at the periphery of the visuo-sensory area, and microphotographs are introduced illustrating this change, and also the corresponding portions of the cortex in anophthalmos. At the abrupt change in lamination, the line of GENNARI suddenly ceases, and the two layers of granules run into one. The statement of LEONOVA that the line of GENNARI

is absent in anophthalmos is disproved by means of microphotographs, and in the following Section by an accurate map of the area containing it (p. 203).

As this investigation is concerned with the general histology of the cortex rather than with its special neuronic structure, no historical account of the latter is introduced.

Section 4 contains a detailed description of the six cases examined by the author, and, from the subject matter of the section, the following conclusions are drawn :—

(1) The "occipital" lamination in the region of the calcarine fissure is a well-defined cortical area.

(2) It occupies—

(a) The body of the calcarine fissure, including the anterior and posterior annectants, and extending upwards to the parallel cuneal sulcus and downwards to the collateral fissure.

(b) The posterior part of the calcarine fissure, extending to the polar sulci surrounding its extremities.

(c) The inferior lip of the stem of the calcarine fissure (including the superficial surface and lower lip of the cuneal annectant), nearly to its anterior extremity, just posterior to which the area tails off to a sharp point.

(3) The approximate outline of this area is consequently pear-shaped, with the apex anteriorly and the thick end at the pole of the hemisphere.

(4) The area is much decreased in extent, but not in distribution, in cases of long standing blindness.

(5) In anophthalmos the area is much contracted as regards both extent and distribution. It occupies the usual position in the stem of the calcarine fissure, but only extends backwards as far as the posterior cuneo-lingual annectant, and it is confined to a portion of the inferior lip of the fissure and to the cortex between this and the collateral sulcus.

It may be added here, being out of place in the general text, that while the visuo-sensory area in the majority of cases conforms to one or other of the figures in the text, it is considerably modified, both in position and extent of distribution, by rare variations of the calcarine fissure. In one case met with recently by the author, an unusual branch of the calcarine fissure subdivided the relatively large cuneus into two nearly equal parts, the special lamination, as is usual, following the course of the branch, and in this case occupying the greater part of the cuneus. The visuo-sensory area in this hemisphere was consequently extremely irregular in shape, and very extensive in distribution.

In Section 5 is given a short account of the method adopted during the present investigation.

Finally, in Section 6, tables of micrometer measurements, taken from the whole of

the visuo-sensory area and from the neighbouring visuo-psychic cortex of the six brains examined, are introduced and discussed. The following conclusions are drawn from these tables :—

(1) In the area of special lamination described in Section 4, in cases of old-standing optic atrophy the line of GENNARI is decreased nearly 50 per cent. in thickness, and the outer granule layer more than 10 per cent.

(2) In the visuo-psychic region surrounding the area of special lamination, old-standing optic atrophy causes no modification of the lamination.

(3) In anophthalmos the conjoined outer granule layer and line of GENNARI (for the granules in the former layer are not sufficiently obvious to admit of easy micrometer measurement alone), are narrowed down to two-thirds of the normal thickness, the other layers of the cortex being approximately unchanged. This amount of narrowing is the same as that found in cases of old-standing optic atrophy.

(4) The majority of the layers of the cortex do not vary appreciably in thickness as a result of age or chronic insanity, but there is an almost exact correspondence between the thickness of the conjoined 1st and 2nd layers of the cortex (outer layer of nerve fibres and pyramidal layer) and the degree of amentia or dementia existing in the patients.

In conclusion, I desire to express my indebtedness to Dr. WIGLESWORTH and Dr. A. W. CAMPBELL, of the County Asylum, Rainhill, Lancashire; to Professor SAUNDBY, of Birmingham, and Dr. C. POWELL WHITE, of Leeds; to Professor WHITCOMBE, of the City Asylum, Winson Green, Birmingham, and Dr. GEO. A. WATSON, of Claybury; to my brother, Dr. CHARLES BOLTON, of University College Hospital; and to Dr. JOB, of Newark-on-Trent, and Dr. S. H. WHITE, of Somerton, for their kindness in supplying me with the tissue made use of during this research.

I have also received most valuable advice and criticism from Dr. WIGLESWORTH, Dr. A. W. CAMPBELL, and Dr. F. J. ALLEN, and especially from Dr. F. W. MOTT, F.R.S., who has not only given me the benefit of his great experience, but has placed at my disposal all the facilities for research provided in the splendidly equipped laboratory of the London County Council at Claybury.

LIST OF REFERENCES.

No attempt has been made to compile a complete list of the hundreds of papers published which have a bearing on the subject. Only the publications directly referred to in the text are included.

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(30.) BOLTON. Journ. Anat. and Phys., January, 1898, and January, 1899.

Description of Illustrations.

Of the 52 illustrations which this paper contains, 37 are drawings, 7 are microphotographs, and 8 are tables.

Drawings.

Figs. 1 and 2 (pp. 172–173) are prepared to illustrate the vascular supply and the commoner vascular lesions of the visual area and neighbouring parts.

Fig. 3 (p. 178) contains reproductions of a few of the more important published cortical lesions resulting in hemianopsia.

Figs. 12–17 (pp. 189–190) illustrate the outer, inner, and lower surfaces of the right occipital lobes of Case 1, and indicate the exact distribution of the visual area in this case.

Figs. 18 and 19 (pp. 190–191) consist of a series of sections through the calcarine fissure of Case 1, and indicate the exact distribution of the special lamination.

Figs. 20–27 (pp. 193–195) refer similarly to Case 2, as also do figs. 28–32 (pp. 196–197) to Case 3, figs. 33–39 (pp. 199–200) to Case 4, figs. 40–42 (201–202) to Case 5, and figs. 43–45 (p. 203) to Case 6.

Microphotographs (*Plates* 9–11).

Fig. 4, Plate 9, gives a low-power view of a Weigert-Pal preparation of the calcarine fissure of Case 2 in the region of the posterior annectant. This is intended to show the general distribution of the special lamination, and also to illustrate the regions of the convolutions which have been used for micrometer measurements.

Fig. 5, Plate 9, and fig. 6, Plate 10, illustrate the abrupt change of lamination, described in the text, which occurs at the periphery of the visuo-sensory area. The section from which fig. 5 was prepared was stained by the Nissl method.

Fig. 6 is a composite microphotograph of duplicate Nissl and Weigert-Pal preparations. The particular case and the exact region of the brain from which each of the sections illustrated was taken is stated in the text as regards both these and the following microphotographs.

Fig. 7, Plate 10, illustrates the general appearances of visuo-sensory cortex in the regions of the convolutions *not* used for the purposes of micrometer measurements.

Figs. 8–10, Plate 11, illustrate the cortex of anophthalmos in the visuo-psychic region, at the change of lamination, and in the visuo-sensory area respectively.

Tables and Tabular Figures.

Fig. 11 (p. 187) illustrates, in the form of a chart for the purposes of comparison, the various published descriptions of "occipital" lamination, the basis of comparison used being the series of layers adopted by the author for micrometer measurement.

Fig. 46, (p. 207), illustrates in chart form the conditions respectively of the line of GENNARI and of this line and the outer layer of granules in the cases described in Section 4.

Figs. 47 and 48 (pp. 209–210) illustrate the relative thicknesses of the different cortical layers in the several regions of the convolutions which are indicated in fig. 4, Plate 9, the basis of comparison being the "side" of a convolution.

Figs. 49 and 50 (pp. 212–215) contain in millimetres the results of the micrometer measurements of the cortex made by the author. The number of regions measured, which is given in the first column of figures in these tables, does not refer to the number of measurements made, but to the actual number of regions examined. In each case several measurements were made, usually from different serial sections, and the average of these was noted.

Figs. 51 and 52 (p. 216) contain, in percentages of Case 1, the measurements contained in the last two tables. A comparison with the chart in fig. 46 (p. 207) will at once demonstrate the atrophy present in the blind cases. No further description of these tables is needed here, as they are fully referred to in the general text.

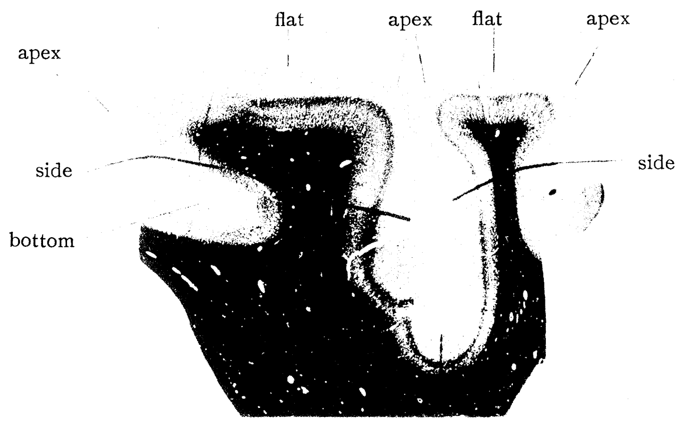


FIG. 4.
(3.3 diameters)

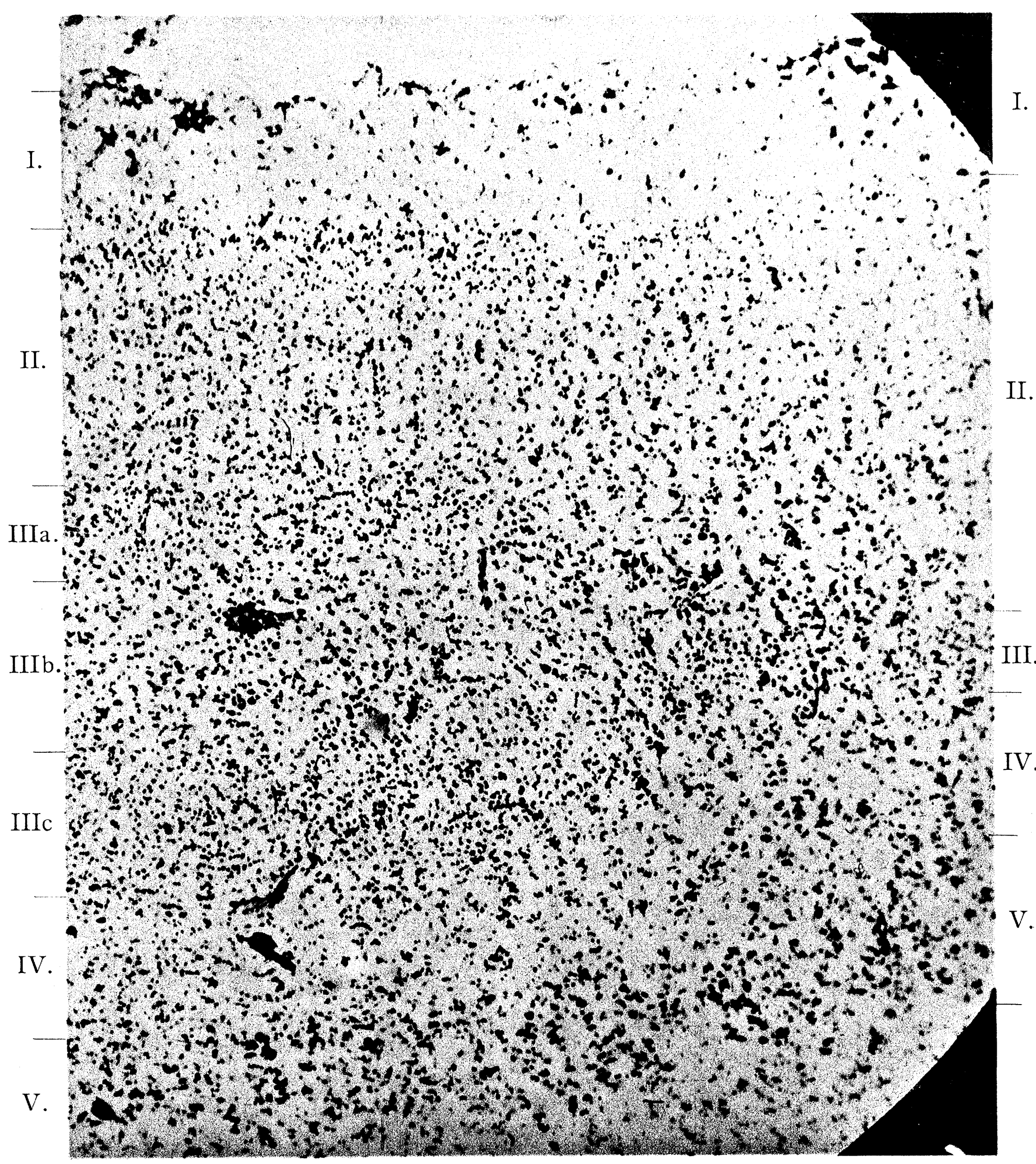


FIG. 5 (80 diameters)

N.B.—Owing to a mistake of the Collotypers, the subdivision of the Cortex into layers, intended to be shown by the marginal lines and numerals, is only very roughly indicated by the lines as printed. This remark applies to Plates 10 and 11 also.

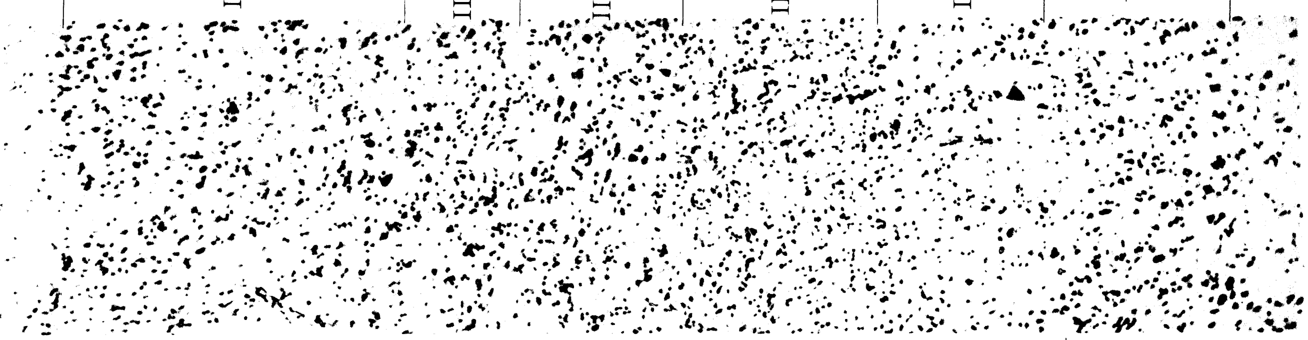


Fig. 7.
(93 diameters)

Fig. 6.
(85 diameters)

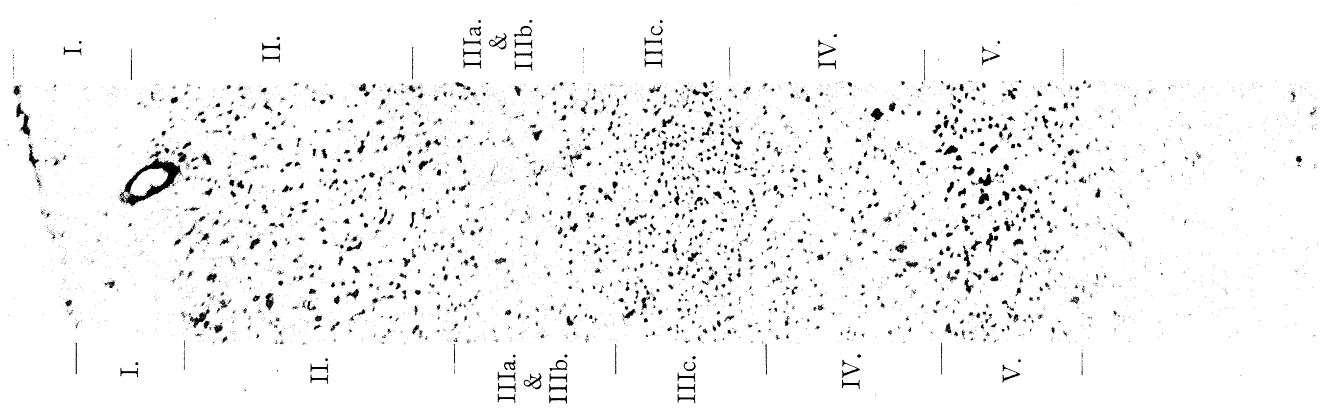


Fig. 10.
(95 diameters)

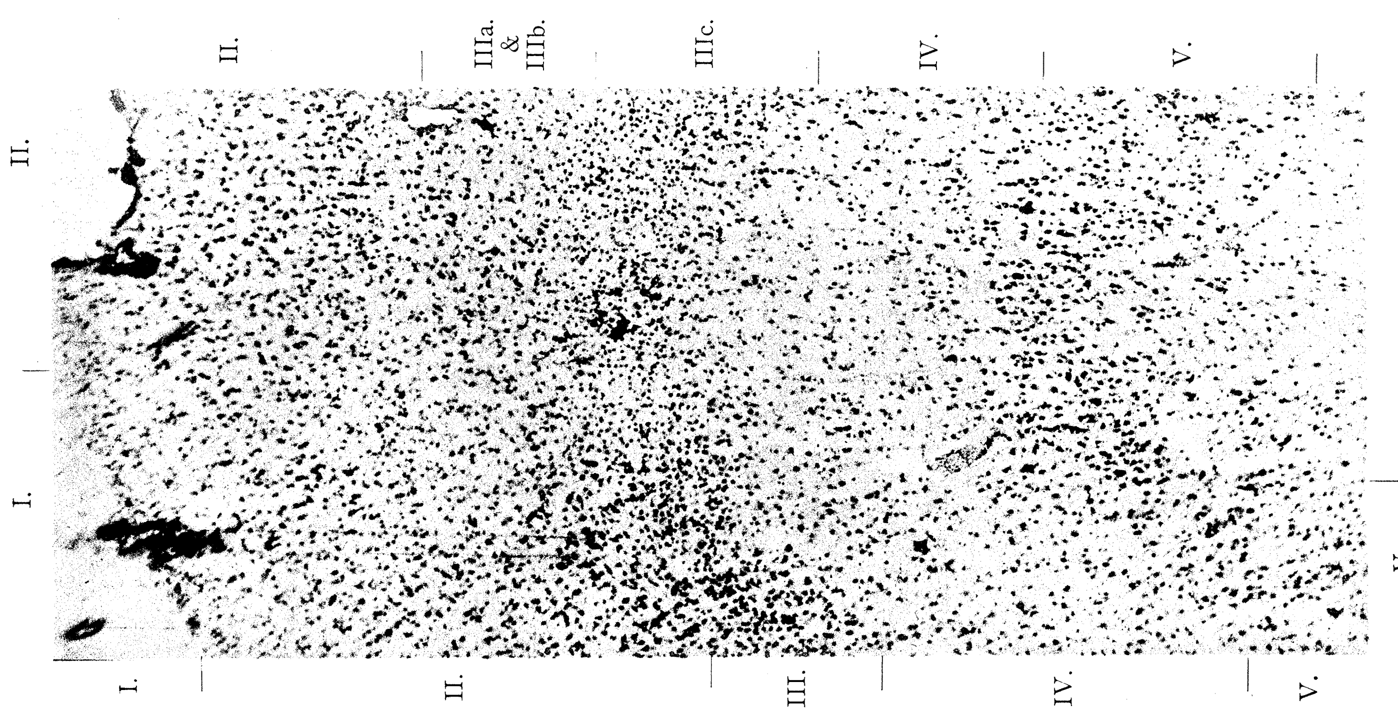


Fig. 9.
(95 diameters)

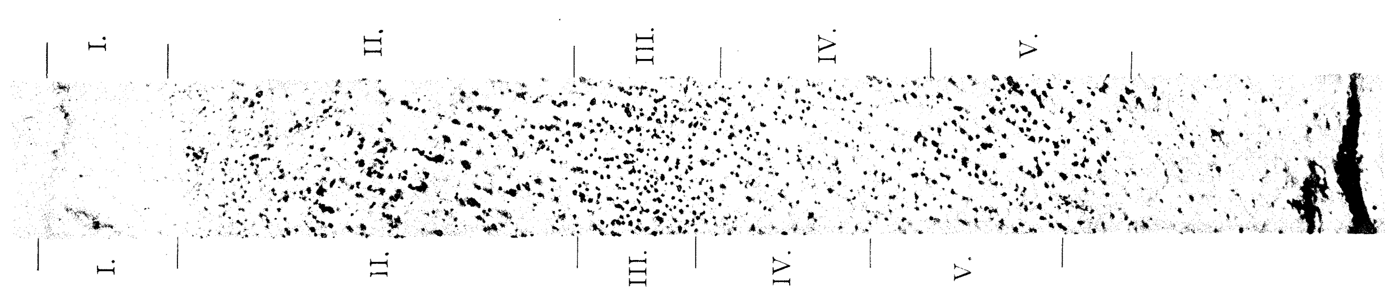


Fig. 8.
(95 diameters)

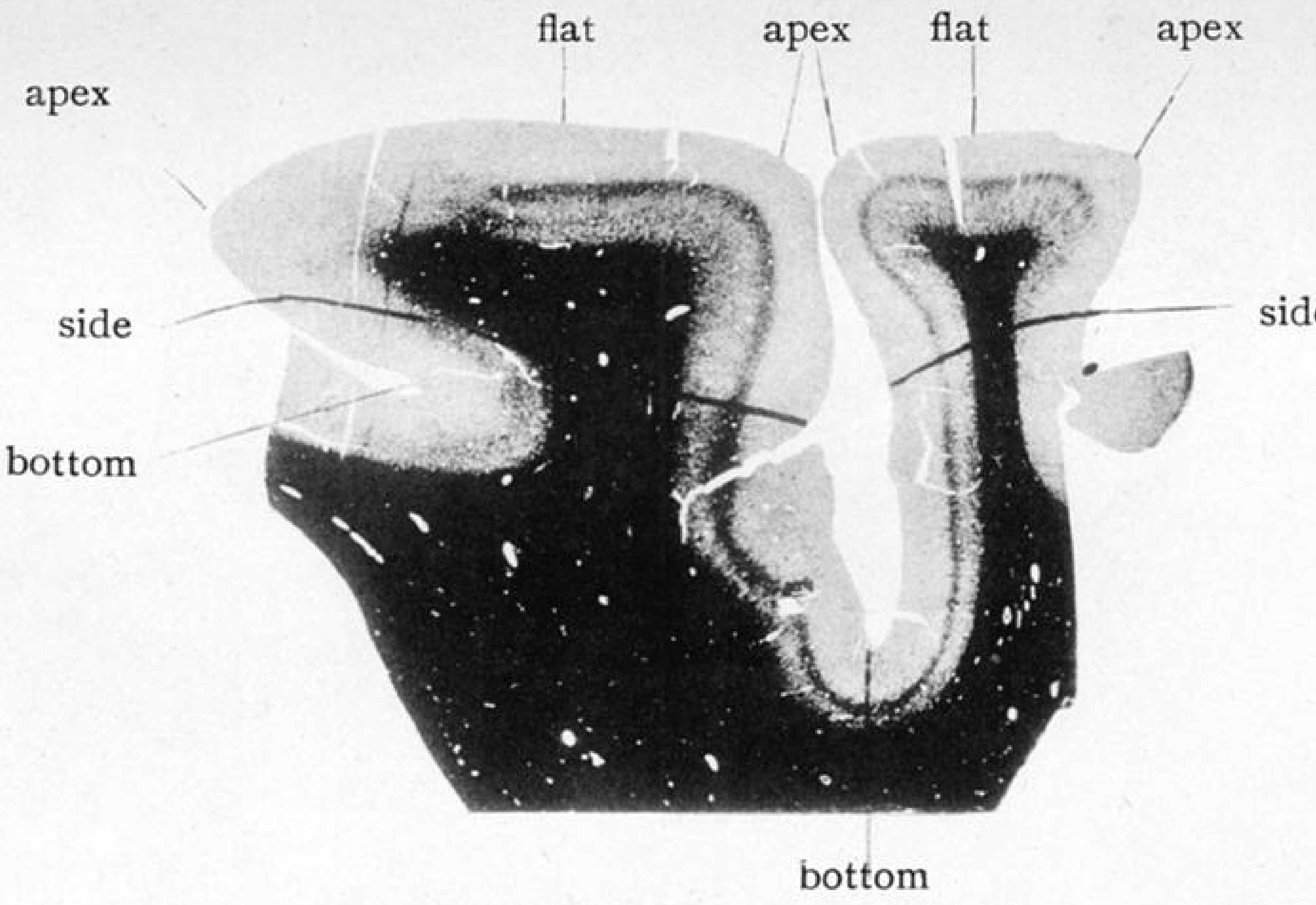
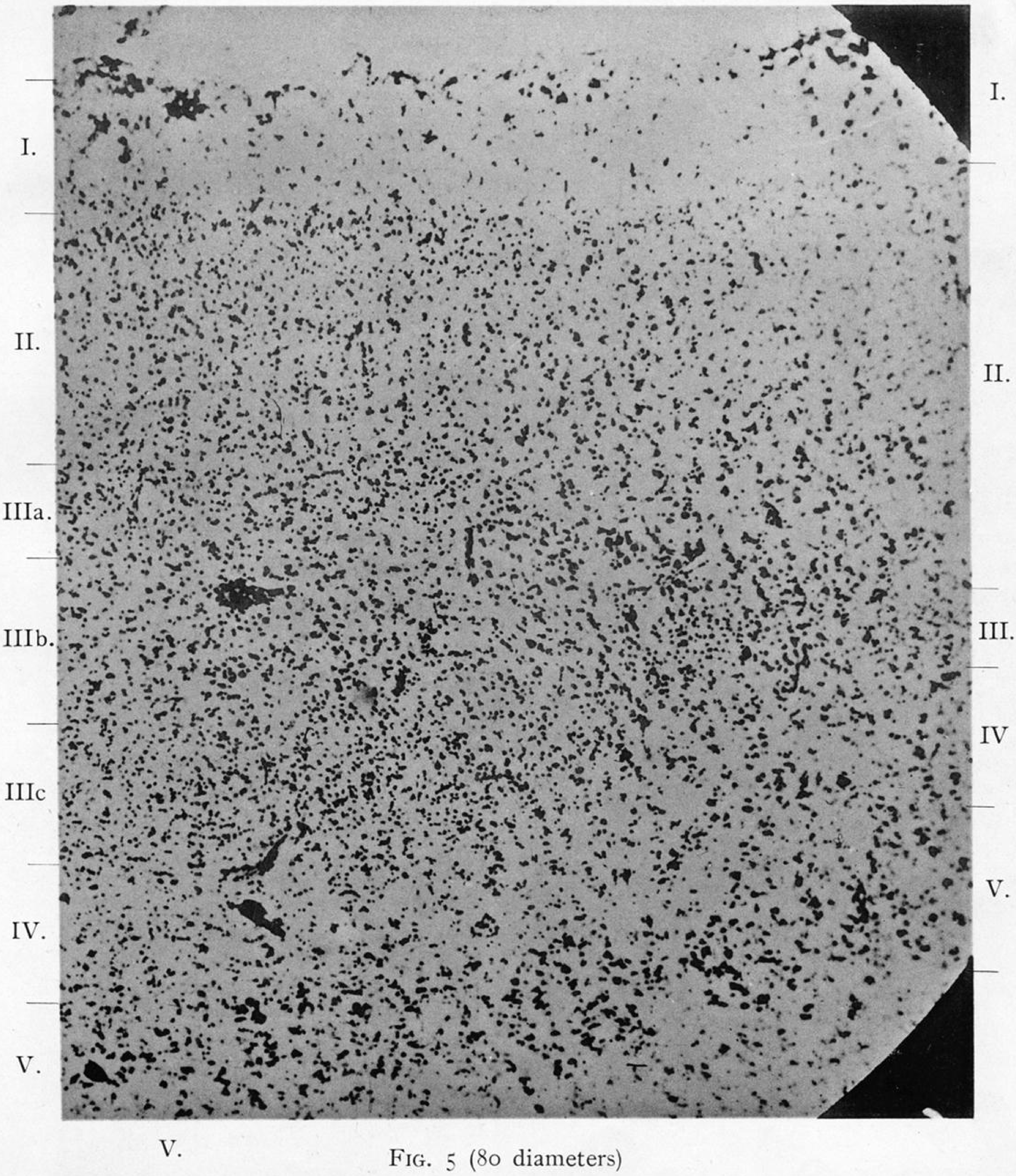


FIG. 4.
(3.3 diameters)



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(85 diameters)

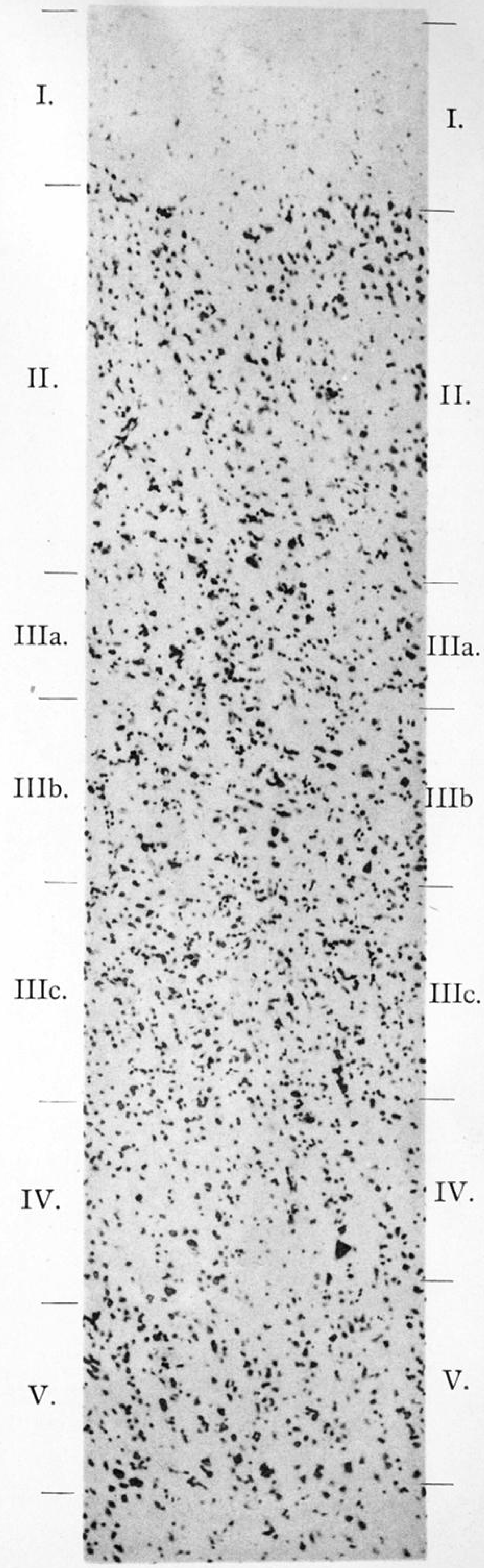

FIG. 7.
(93 diameters)

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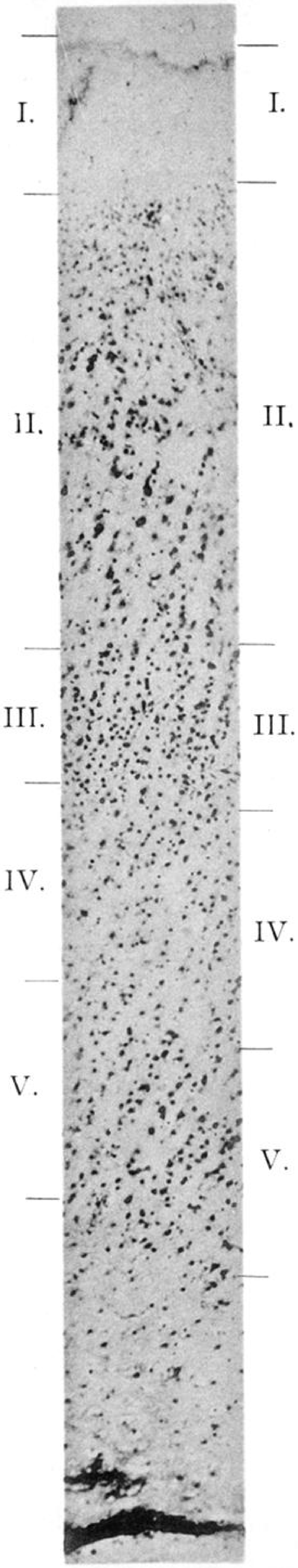


FIG. 8.
(95 diameters)

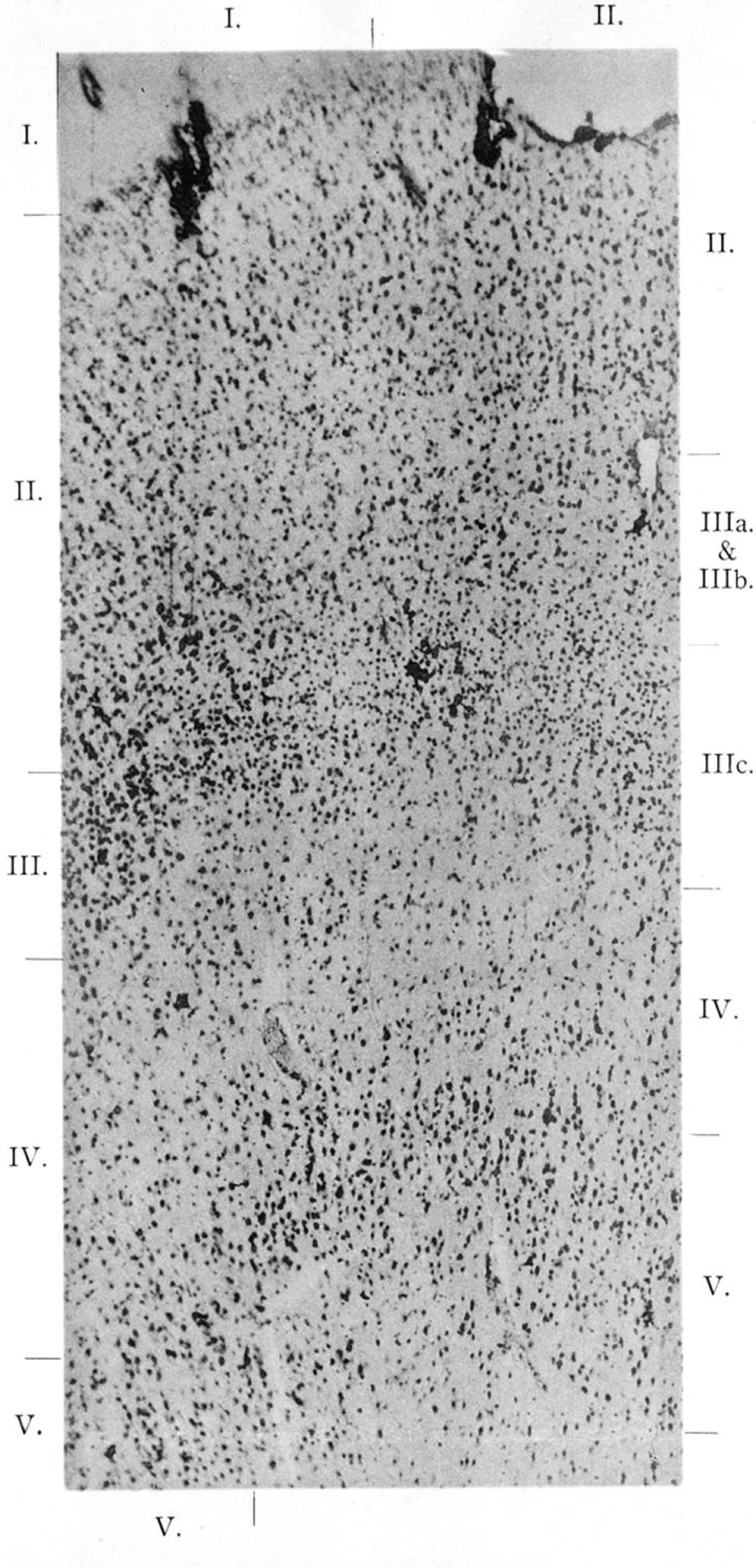
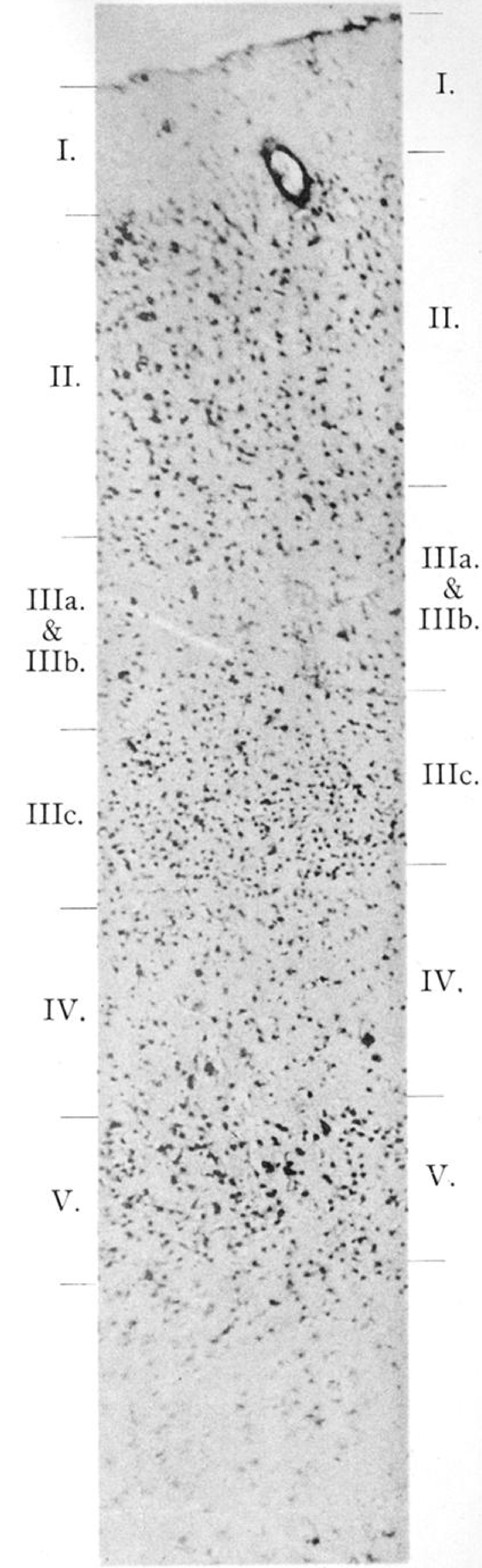


FIG. 9.
(95 diameters)



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(95 diameters)

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